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AVIATION VERSUS SUBMARINES

by

I. M. Sotnikov and N. A. Brusentsev

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The contemporary state and the means of developing antisubmarine aircraft, helicopters and airships of capitalist governments, and also the aviation means of detecting and destroying submarines, of organizing conflicts with submarines, the methods of operational utilization and tactical application of aircraft in antisubmarine operations are ~~brought to light~~. The book is intended for Army and Navy personnel and readers, who are interested in the naval fleet and its aircraft.

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U. S. BOARD ON GEOGRAPHIC NAMES TRANSLITERATION SYSTEM

Block	Italic	Transliteration	Block	Italic	Transliteration
А а	*А а*	A, a	Р р	*Р р*	R, r
Б б	*Б б*	B, b	С с	*С с*	S, s
В в	*В в*	V, v	Т т	*Т т*	T, t
Г г	*Г г*	G, g	У у	*У у*	U, u
Д д	*Д д*	D, d	Ф ф	*Ф ф*	F, f
Е е	*Е е*	Ye, ye; E, e*	Х х	*Х х*	Kh, kh
Ж ж	*Ж ж*	Zh, zh	Ц ц	*Ц ц*	Ts, ts
З з	*З з*	Z, z	Ч ч	*Ч ч*	Ch, ch
И и	*И и*	I, i	Ш ш	*Ш ш*	Sh, sh
Й й	*Й й*	Y, y	Щ щ	*Щ щ*	Shch, shch
К к	*К к*	K, k	Ъ ъ	*Ъ ъ*	"
Л л	*Л л*	L, l	Ы ы	*Ы ы*	Y, y
М м	*М м*	M, m	Ь ь	*Ь ь*	'
Н н	*Н н*	N, n	Э э	*Э э*	E, e
О о	*О о*	O, o	Ю ю	*Ю ю*	Yu, yu
П п	*П п*	P, p	Я я	*Я я*	Ya, ya

* ye initially, after vowels, and after ъ, ь; e elsewhere. When written as ё in Russian, transliterate as yё or ё. The use of diacritical marks is preferred, but such marks may be omitted when expediency dictates.

Translator's note: On several occasions, symbols found in formulae and calculations appear to have been rendered incorrectly in the original document. They will be shown exactly as they appear in the original.

LIST OF ACRONYMS APPEARING IN THIS DOCUMENT

КПСС = CPSU = Communist Party of the Soviet Union
ПЛО = PLO = Antisubmarine Defense
УКВ = UKV = Ultrashort-Wave
АРК = ARK = Automatic Radio Compass
КВ = KV = Shortwave
ДЭШ = DASH = Drone Antisubmarine Helicopter
МАШ = MASH = Manned Antisubmarine Helicopter
РДП = RDP = Snorkel
АНТАК = ANTAC = Air Navigation and Tactical Air Control
ТВД = TVD = Turboprop Engines
НВАР = HVAR = High-Velocity Aircraft Rockets
АД = AD = Automatic Detection
РГБ = RGB = Sonobuoy
ПЛАРБ = PLARB = Submarine Nuclear Missile Base
ЛААВ = LAAV = Light Airborne ASW Vehicle
ИСЗ = ISZ = Artificial Earth Satellite
КП = KP (CP) = Command Post
ГТД = GTD = Gas Turbine Engines
УПС = UPS = Boundary Layer Control
УЛО = ULO = Flow Lamellarization of Control Systems
ГАС = GAS = Sonar Equipment
СВП = SVP = Air-Cushion Aircraft
ТВД = TVD = Turbofan Engine
ТРДД = TRDD = Ducted-Fan Engine
ТРД = TRD = Turbojet Engine
МАД = MAD = Magnetic Anomaly Detector
ОГЛС = OGLS = Dipping Sonar
БГЛС = BGLS = Towed Sonar
ШП = ShP = Sound-Bearing (Listening Sonar)
ГЛС = GLS = Sonar
ОГАС = OGAS = Dipping Sonar Transducer
РЛС = RLS = Radar Stations
ОКГ = OKG = Optical Quantum Generator
ППС = PPS = Search-Aiming System
ИНС = INS = Inertial Navigation System

ВДНИ = VDNI = Bearing, Range and Course Indication

ПЛУР = PLUR = Antisubmarine Guided Missile

АППУГ = APPUG = Carrier-Based Hunter-Killer Antisubmarine Group

ВМБ = VMB = Naval Base

БИП = VIP = Combat Information Center

ЛАД = LAD = Location Aid Device

АУС = AUS = Carrier Striking Forces

ВКП = VKP = Mobile Command Post

ГКП = GKP = Main Control Room

ОВМС = OVMS = NATO Allied Naval Forces

УРО = URO = Guided-Weapon Destroyer

The contemporary state and the means of developing antisubmarine aircraft, helicopters and airships of capitalist governments, and also the aviation means of detecting and destroying submarines, of organizing conflicts with submarines, the methods of operational utilization and tactical application of aircraft in antisubmarine operations are brought to light.

The book is intended for Army and Navy personnel and readers, who are interested in the naval fleet and its aircraft.

PREFACE

Submarines are a threatening means of conflict on sea and oceanic communications. Their role among other naval forces continuously increases. This is confirmed by the experience of two World Wars and the rate of submarine development after the Second World War.

The losses of world commercial tonnage only from German submarines for the First World War (1914-1918) constitute more than 13.2 million gross registered tons. Furthermore, from the submarines of all the belligerent governments 162 combat surface vessels perished, including 12 battleships, 23 cruisers, 39 destroyers and others.

The losses of commercial tonnage from submarines for the Second World War (excluding the Soviet Union) were about 22 million gross registered tons. Furthermore, from the submarines of all the belligerent governments (excluding the Soviet Union) 320 surface ships were lost, including 3 battleships, 15 aircraft carriers, 32 cruisers, 122 destroyers and others.

The introduction in the postwar period into shipbuilding (especially into submarine building) of nuclear power engineering and of naval equipment with nuclear missiles radically changed the conditions and the nature of armed conflicts at sea and led foreign specialists to a revaluation of the value of the varieties of naval forces and of the methods of their utilization.

The main type of naval forces of the greatest capitalist sea powers is becoming submarines, which actually determine the striking power of a navy.

Leaders of capitalist sea powers use achievements in submarine building in their aggressive goals to create powerful offensive weapons. In the USA today the building of the atomic submarine fleet rapidly progresses. England and France have started building submarines with nuclear power engineering. The creation of such vessels is planned in the Netherlands, FRG and Italy.

The military preparations of capitalist governments, and primarily the USA, have taken on enormous dimensions. They considerably increase military budgets and continue the intensive armament race. For the armament race in the USA from the 1946 to 1968 fiscal years there were spent about 1050 billion dollars, which by two times exceeds the expenditures of the USA on military needs during their whole history before 1945, including the First and Second World Wars. Especially increased was the armament race in connection with escalation of aggressive warfare in Vietnam. According to the military budget for the USA for the 1969/70 fiscal year, the Pentagon has received almost 70 billion dollars. In the budget the expenditures have not been included for the building of military installations and other military goals, estimated in the several billions of dollars.

In the unsuccessful quests of means of rescuing the doomed capitalism from ruin, reactionary forces strive to do everything to restrain the progressive development of society on the way to socialism and communism, to destroy the revolutionary achievements of the nation, to restore the undivided supremacy of monopolistic capital. For the achievement of its criminal intentions, bosses of imperialistic governments do not have any scruples and increasingly count on armed intervention into the affairs of other nations, on the preparation and the unleashing of war against socialist countries.

For this goal, the ruling circles of the USA created around the socialist countries more than 2200 military, air force and naval bases and strong points. The imperialists are striving to enlarge the aggressive military-political blocks established under the protection of the United States of America, directed primarily against the Soviet Union and other socialist countries.

In recent years, the imperialists along with preparing for world war have reverted to open aggressive operations in various areas of the world. The most cynical aggressive main point of imperialism is manifested in robber war of the USA in Vietnam, in the aggression of Israel, which is an instrument of the imperialists of the West, upon the Arabic countries.

Especially dangerous for the emergence of a new world war is the revival of West German militarism, the creation of a mass Bundeswehr, the aspiration of Bonn revarchists to get nuclear weapons into their own hands.

Contemporary American imperialism has the most reactionary and aggressive character. On their naval forces, and, in particular, on atomic missile submarines, the aggressive circles of the USA laid the role of one of the main strategic means in future war.

Atomic power plants make it possible for submarines to stay underwater for unlimited time and to pick up considerable speed of motion underwater. Contemporary submarines can submerge to a great depth. All this extremely complicates the search for submarines. In connection with this, in the overall system of aggressive war measures of imperialistic governments, considerable attention has been allotted to the development of forces and means of conflicts with contemporary submarines and, especially, to the frantic development of antisubmarine aviation.

For a conflict with submarines aviation was used even in the First World War.

The combat operations of English aircraft against German submarines began in 1917. During the period from May to September of 1917, searching for submarines it flew about 325,000 miles (601,250 km) over the sea. It ultimately detected 65 submarines, attacked 46 of them, sank 6 submarines. In all during the war aircraft sank 10 submarines, which constitute 3.4% of the overall losses.

In spite of the very modest results, the general effect of aircraft on the course of antisubmarine warfare was highly evaluated.

Historians of the First World War record that only a single strike from the air considerably hampered submarine operations in the coastal regions, even after their being supplied with antiaircraft periscopes.

In the Second World War aircraft in the conflict with submarines gained great success.

Of the 781 German submarines destroyed by the allies in the course of the Second World War, the coastal-based aircraft sank 329 (42.2%); shipborne antisubmarine aircraft - 46 (5.9%), totaling 375 (48.1%). Furthermore, with the joint operations of aircraft and of surface ships 48 (6.1%) were sunk.

The data about the German submarine losses from Anglo-American protection and support aircraft deserve attention, which characterize the growth of the effectiveness of antisubmarine aircraft, in the table given below.

Period	Total hours accumu-lated by aircraft	Submarines sunk	Submarines damaged	Total aircraft losses	Losses of aircraft per one sunk sub-marine	Flying time per every sunk submarine
1.06.42-30.04.43: (11 months)	58.525	23	16	36	1.5	2544
1.05.43-1.08.43 (3 months)	19.329	10	8	10	0.9	1757
2.08.43-31.05.44 (10 months)	43.534	25	15	24	0.9	1643
Total............	121.388	58	39	70	1.2	2093

Supporters and defenders of the important role of aircraft in conflict with submarines, while pointing out the considerable successes of aircraft in the destruction of submarines in the Second World War, assert that contemporary antisubmarine aircraft, as before, will play the most important role in the conflict with enemy submarines.

For the last 5-7 years, in the open press of the USA and of Great Britain, of Canada and of other NATO countries rather often, with high controversial incandescence, questions were discussed about the ways of practical solution to the problem of personnel, of number and forms of utilization of forces and of means for conflict with submarines.

The programs for developing the naval fleets of the NATO countries and the realization of these programs for the past five to six years confirm that the naval forces commands of the USA, England, and in all of NATO are striving to create well-balanced antisubmarine forces, which should include: a global system of stationary facilities for detecting and identifying submarines, antisubmarine aircraft, antisubmarine surface ships and antisubmarine submarines.

As it is possible to judge from numerious materials of the open press of the USA, of Great Britain and of other NATO countries, to the

technical perfection of antisubmarine aircraft, helicopters and their weapons is given considerable attention, and for these goals large resources are released.

The material available in the press about the antisubmarine aircraft of capitalist governments has been described by separate journal articles, by brief information or by small sections in books on antisubmarine conflict.

In this book an attempt is made to correlate the materials of the printing sources dedicated to antisubmarine aircraft of the naval forces of imperialistic governments, and to illuminate:

- the views of military and naval specialists and the official positions concerning operational-tactical destination and role, organization and utilization of aircraft and airships in antisubmarine warfare;

- contemporary status and the probable ways of developing the tactical-technical characteristics of antisubmarine aircraft, helicopters and airships of the USA, Great Britain and other capitalist countries;

- the status and perspectives of developing aviation means of detecting and destroying submarines;

- the operational-tactical capabilities of antisubmarine aircraft, helicopters and dirigibles, the means of their operational use and tactics of combat application in antisubmarine operations, by the experience of studies of foreign fleets.

Capitalist monopolies of the USA and their partners do not want to reconcile themselves to the existence of a world socialist system and openly declare their insane plans of eliminating it by means of war with the Soviet Union and the other socialist governments. However, they understand that under conditions of the immeasurably

increased military and economical power of the USSR and the entire socialist system, they can expect the crushing blow of our nuclear missile forces including submarines.

The aggressive politics of imperialistic governments, and primarily the USA, creates a real threat to peace. Therefore, the CPSU [Communist Party of the Soviet Union] manifests relentless care concerning the strengthening of the defense power of our country, which found a brilliant expression in the summary report of the Central Committee of the XXIII Congress of the CPSU: "The Party will henceforth in every possible way strengthen the defense capability of the Soviet Union, multiply the power of the Armed Forces of the USSR, maintain a level of combat troop readiness, which reliably guarantees the peace work of the Soviet people."

Under conditions of the continuing aggravation of the international situation, of particular significance is a correct evaluation of enemy forces, knowledge of his strong and weak sides. By knowing up-to-date combat technology of the imperialistic governments, it is possible to correctly judge their actual capabilities and the means of conflict with it. It is natural that our military sailors and aviators should well know the antisubmarine aviation of foreign governments.

This book consists of three chapters and a conclusion. The first and third chapter are written by Colonel I. M. Sotnikov (retired) and the second chapter and the section, "Antisubmarine Dirigibles," are written by Lt. Colonel N. A. Brusentsev, candiate of military sciences and engineer.

Large assistance during the preparation of this book was rendered by Lt. General of Aviation N. S. Zhitinskiy, Colonels V. P. Zhukov, N. M. Lavrent'yev and G. M. Shvarev, who in the process of survey and review gave a number of valuable opinions, for which the authors express to them deep gratitude.

CHAPTER I

THE RECENT STATUS AND PERSPECTIVES OF THE DEVELOPMENT OF ANTISUBMARINE AIRCRAFT, HELICOPTERS AND DIRIGIBLES BY CAPITALIST COUNTRIES

The Development of the Antisubmarine Aviation of Capitalist Countries in the Postwar Years

In the development of the antisubmarine aviation of the USA, England and other capitalist countries during the period after the Second World War, it is possible to trace two stages, coinciding in time with the development stages of the Navy of the USA.

The first stage (1946-1955) is characterized by the building of heavy aircraft carriers, diesel submarines and other classes of vessels, besides battleships. At this time large-scale experimental works were developed to create shipborne atomic power plants and to design experimental atomic submarines. Simultaneously, the naval forces of the USA, Great Britain, France, Canada and other NATO countries in growing rates are being enlarged with various forces and means of antisubmarine defense [PLO] (ПЛО) for conflict with diesel submarines.

By creating new land-base and carrier-based antisubmarine aircraft, the English and the Americans, by using the PLO experience of the aviation conflict with German submarines in the Second World War, strove firstly to guarantee them long range and duration of flight, considerable combat load and simultaneously, to equip them with up-to-date means of detection and destruction of submarines.

After the Second World War, the antisubmarine seaplane Martin PBM-5 "Mariner" was retained in the inventory and continued to be built. In the beginning of 1951, to replace the "Mariner" by order of the Navy of the USA the Martin firm began series production of the P5M-1 "Marlin" seaplane with better tactical flight qualities in comparison with the PBM-5 "Mariner."

In June 1954, for the armament of land-base aviation the Martin Tp5M-2 "Marlin" seaplane went into production having a improved search radar. In October 1952, the Martin firm finished the design and began building the experimental multipurpose, including the solution of antisubmarine problems, P6M-1 "Sea Master" seaplane with speed up to 960 kph (Fig. 1). As a result of a number of structural defects, in 1955 and 1956 during tests two experimental aircraft suffered a catastrophe. In all, 14 "Sea Master" seaplanes were built, and this ended their manufacture.

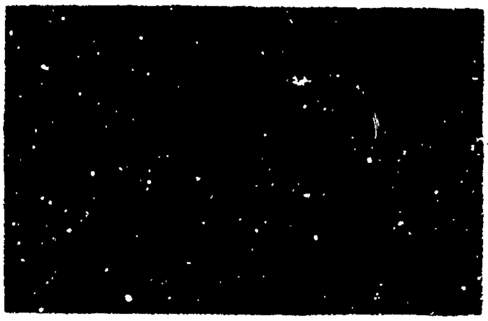

Fig. 1. The multipurpose Martin "Sea Master."

After the failures from the Martin P6M-1 "Sea Master," seaplanes were not developed again in the USA. The latter was explained by the fact that antisubmarine aircraft with wheel-type landing gear at equal take-off weights with seaplanes have higher tactical flight characteristics.

In December 1945, in large quantities for the inventory of land-based aviation the Lockheed P2V-1 "Neptune" patrol aircraft began to be produced (Fig. 2). This aircraft up to the beginning of the

Sixties was the primary type of aircraft for the land-based aviation of the Navy of the USA and was a unique stand, on which was tested new equipment for antisubmarine aircraft.

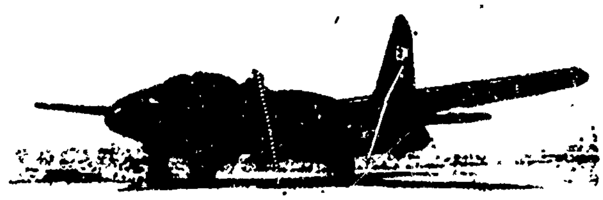

Fig. 2. The Lockheed P2V-1 "Neptune" patrol aircraft.

From December 1945 to December 1963, the Lockheed firm conducted six modifications of the original variant of P2V-1 aircraft, as a result of which its flight performance and combat qualities were substantially improved.

For the changeover from carrier-based antisubmarine aircraft of the Second World War period, the Grumman "Avenger" was replaced in the inventory in 1949 in the USA by the Grumman "Guardian," which was built in two variants. The AF-2W, having search radar, was intended only for submarine search, and the AF-2S for the destruction of a discovered and observed submarine. Unlike the AF-2W it has only bombing armament. Thus, search and destruction of submarines had to have been carried out by the joint operations of two aircraft. This was inconvenient and disadventageous: the breakdown of any of the two aircraft disrupted the execution of a combat mission.

In 1952, in the USA the aircraft AF-3S was manufactured, which was a modification of the AF-2S. On this aircraft was mounted equipment for both search and destruction of the submarines.

In Great Britain soon after the termination of the war, the Avro firm constructed and introduced into the inventory of the Coastal Command the four-engine patrol antisubmarine "Shackleton," which possessed long range and powerful armament for conflict with submarines.

For the changeover from an aircraft of the war years, the "Swordfish," by order of the English Admiralty, Fairey and Short developed several types of carrier-based antisubmarine aircraft, including the "Firefly" the A.S.Mk5 and A.S.Mk7, the Short "Sea Mew." But after the manufacture of a small number of these aircraft, as without prospects from the point of view of the capability of their modification, they were removed from production and armament.

By order of the Admiralty, Fairey developed the carrier-based antisubmarine "Gannet" A.S.Mk1. In September 1949 it made its first flight. In 1953 the mass-produced "Gannet" A.S.Mk1 began to appear in the inventory of aircraft carriers of Great Britain's Navy. During the subsequent years several modifications of this aircraft were developed and constructed.

The second stage of the development of antisubmarine aircraft is connected with the beginning of building of new submarine forces of the USA. In 1956, in the USA an atomic missile-carrying fleet began to be created, the foundation of which should have been comprised of atomic missile submarines. It is assigned the ever greater role of inflicting strategic nuclear strikes against objects in the territory of the Soviet Union and the other countries of socialism.

But American naval specialists not without reasons considered that if the USA and their NATO allies started a war against the countries of socialism, they would encounter the crushing counter-measure of the Soviet Union and the other socialist countries by the utilization of contemporary forces and combat means, including atomic submarines. In connection with this, in the middle of the Fifties in the USA requirements for diversified antisubmarine forces including antisubmarine aircraft sharply increased.

In 1957 Lockheed by order of the U. S. Navy began the project of development of the new land-based patrol Lockheed P-3A "Orion" with more lifting capacity than the Lockheed P2V "Neptune," having subsonic speed and long range able to carry various search equipment

and a powerful means of destruction, including atomic depth charges. Simultaneously, the Grumman S-2 "Tracker," accepted into the inventory as a carrier-based antisubmarine aircraft in the beginning of 1953, was being repeatedly modified.

In Canada on the basis of a passenger aircraft, the "Britinnia" was built and by May 1958 s manufactured serially as the patrol aircraft CL-28 "Argus,"

In France the carrier-based antisubmarine aircraft Breguet 1050 "Alize," was built by Breguet which in May 1959 began to appear on aircraft carriers and up to the present time is in the inventory of the French Navy.

In other allied and dependent upon the USA countries (Italy, the Netherlands, Portugal and others) carrier-based and coastal-based antisubmarine aircraft were not built, but used were the American Lockheed P2V-7 "Neptune," the Grumman S-2 "Tracker" and the English Fairey "Gannet" and Avro "Shackleton."

Antisubmarine helicopters first appeared in the inventory of the USA antisubmarine forces at the beginning of the Fifties.

On the basis of the S-55 helicopter Sikorsky developed and constructed the first antisubmarine helicopter, the HO4S-1, on which sonar was mounted. In following, two modifications of this helicopter were constructed, the HO4S-2 and the HO4S-3.

The aviation command of the U. S. Navy favorably evaluated the advantages of antisubmarine helicopters:

- the search speed of an antisubmarine helicopter, which exceeds the speed of antisubmarine ships, made it possible to arrive considerably faster at a region, where other means detected or could supposedly find a submarine;

- the invulnerability of a helicopter on the part of a submarine;

- the hydrophones of antisubmarine helicopters are not subjected to power system interferences, which makes it possible to successfully use the capabilities of the sonars of antisubmarine helicopters;

- within the limits of equal tactical radii of operation from an aircraft carrier, antisubmarine helicopters having sonar are more effective during the search and destruction of submarines than carrier-based antisubmarine aircraft.

- the antisubmarine helicopters are considerably cheaper than carrier-based antisubmarine aircraft and many times cheaper than the surface antisubmarine ships.

On the basis of the experience of the U. S. Navy, in Great Britain accepted into the inventory of aircraft carriers was the antisubmarine helicopter, "Whirlwind" Mk7, like the HO4S, built by Westland,[1] under license acquired in the USA. A license to manufacture for the Japanese Navy HO4S helicopters was also acquired by the Japanese company, Mitsubishi.

The first types of antisubmarine helicopters, just as carrier-based antisubmarine aircraft, were manufactured in the USA in search and strike variants.

In the beginning of 1954 into the inventory of the U. S. Navy was accepted the SH-34 antisubmarine helicopter, developed on the basis of the S-58 helicopter. On SH-34 helicopters were installed: an automatic stabilization system with respect to the assigned course, pitch and roll; a Doppler radar set, an automatic pilot and

[1]Before the beginning of the output of the "Whirlwind" antisubmarine helicopters, Westland under licence built Sikorsky S-54 helicopters.

an automatic machine for maintaining the steadiness of the performance of the power system; a [UKV] (УКВ) ultrashort-wave radio direction finder, an automatic radio compass [ARK] (АРК), a system of short-range navigation "Tacan" and a UKV and [KV] (КВ) shortwave band set.

The SH-34 helicopters could fly day and night under clear and severe weather conditions, perform flight with high accuracy at a speed of up to 150 kph at altitudes of 50-60 m, go to an assigned point of the sea and hover over it at an altitude of 15 m with the sonar lowered to detect a submarine.

The SH-34 type helicopters were manufactured under license in Great Britain ("Wessex"), in Canada (CHSS-1) and in Japan and were used in other capitalist countries up to 1964, and in a number of countries are being used today.

Toward the end of the Fifties in the USA, and in Great Britain they finally went on to build multipurpose, search and strike anti-submarine aircraft and helicopters.

At the end of 1957 by order of the U. S. Navy on the basis of the S-61B helicopter Sikorsky began to develope a search and strike antisubmarine helicopter. In September 1961, the first models of the series SH-3A "Sea King" (company designation HSS-2) were turned over to the U. S. Navy. Since the end of 1963, the Canadian aircraft building company, United Aircraft Canada Ltd., under license built the SH-3A "Sea King" helicopters (company designation CHSS-2) for the Navy of Canada. In August 1962, Sikorsky sold 11 HSS-2 helicopters to the Navy of Japan. The Japanese company Mitsubishi simultaneously acquired a license to build this helicopter in its plants.

The beginning of development of heavy helicopters in France is attributed to 1955, when by order of the military command of aircraft building the French company of Sud-Aviation undertook the development of a helicopter for the Navy and the Air Force. Constructed were two experimental models of the "Frelon" helicopter (a

take-off weight of 7 t, a useful load of 2.5 t), which in the beginning of 1959 passed flight tests. But the "Felon" did not satisfy the requirements of all the armed forces of France. In 1961 was begun the building of two new experimental models of the SA-3210-01 all-weather "Super Frelon" helicopters with high lifting capacity, speed and range. The building of the experimental models of the "Super Frelon" helicopter was assumed by Sikorsky (the manufacture of the rotor hub and rotor blade) and the Italian Fiat Company (the manufacture of the main reduction gear). In December 1962, the flight tests of the experimental models of the SA-3210-01 helicopter were begun, which showed that, in terms of their qualities, these helicopters surpass American helicopters of the same class

In 1958-1959 in the USA and Great Britain, a decision was made to arm with helicopters the being modernized destroyers, destroyer escorts and frigates, built during the Second World War, in order to increase their capabilities in conflict with submarines and thereby to prolong the period of their stay in combat strength of the fleets. Furthermore, in the USA the indicated vessels had unmanned radio-controlled helicopters, which received the code designation DASH.[1]

By contract with the U. S. Navy, Gyrodyne developed and built three models of radio-controlled helicopters, QH-50A, QH-50B and QH-50C. The QH-50C helicopter in April 1961 performed the first flight with a safety pilot aboard, and in January 1962 one of the QH-50C helicopters performed a completely radio-controlled flight, i.e., without a pilot aboard. In the beginning of 1962, QH-50C helicopters were accepted into the inventory of the U. S. Navy. In January 1963, the QH-50C carried out radio-controlled overflight from the island of San Clemente (California) to a ship.

According to plans, the U. S. Navy planned to arm 279 ships

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[1]DASH - Drone Antisubmarine Helicopter.

with the DASH system for which by the program of the introduction of the DASH weapon system it was proposed to build 900 radio-controlled antisubmarine helicopters at a rate of two operational and one spare for every ship.

In the English fleet with respect to a number of reasons, into the inventory of antisubmarine vessels was accepted the manned Westland helicopter, "Wasp" A.S.1, and the weapon system bearing the designation MASH.[1]

The Contempory State of the Antisubmarine Aviation of Capitalist Countries

Coastal-Based Antisubmarine Aircraft

The Lockheed P2V "Neptune." Accepted into the inventory of the land-based aviation of the U. S. Navy at the beginning of 1945, the Lockheed P2V "Neptune" until recently was the most widespread patrol aircraft of the U. S. Navy (Fig. 3). Of six modifications of this aircraft, four, including the P2V-7 "Neptune," are antisubmarine variants. The P2V was put out by Lockheed serially near the end of 1963. In all more than 1,000 aircraft of all the versions were constructed, of which 838 were acquired by the U. S. Navy. The P2V "Neptune" to the present time is in the inventory of the fleets of Australia and Argentina, Brazil and the Netherlands, Canada and Portugal, France and Japan.

Fig. 3. The land-based Lockheed P2V-7 "Neptune" patrol aircraft.

[1]MASH - Manned Antisubmarine Helicopter.

The wide prevalence of the P2V "Neptune" is not only caused by its qualities. This is connected largely with the dictates of the USA with respect to many capitalist countries - participators of the aggressive blocks, created and directed by the USA.

According to its structural configuration, the P2V-7 "Neptune" is a twin-engined all-metal aircraft with mid-wing arrangement and a standard tricycle landing gear. Like all previous versions, the P2V-7 can be used both for antisubmarine patrolling - the main purpose, and for mine laying and torpedo-bombing attacks on ships at sea.

For search and identification of submarines, the aircraft has a radar set, an airborne magnetometer, radio intelligence equipment, marker and sonobuoys, "Jezebel" and "Julie" systems. To destroy submarines, on the aircraft can be taken two homing antisubmarine torpedoes, depth charges, including atomic.

The navigation and flight equipment on the "Neptune" makes it possible to perform flights at night and in severe weather conditions. The aircraft has the "Loran" long-range naviation system. The aircraft is usually operated at airfields with a hard surface.

~~The P2V-7 "Neptune" antisubmarine aircraft to the present time~~ are in the inventory of the U. S. Navy.

The Avro "Shackleton" M.R.3. The patrol bomber, antisubmarine aircraft "Shackleton" (Fig. 4), is a version of the English "Lancaster" bomber widely used during the Second World War.

Fig. 4. Avro "Shackleton" M.R.3 patrol aircraft.

The first flight of the experimental "Shackleton" M.R.1 was in 1949 the "Shackleton" M.R.2 in 1952, the "Shackleton" M.R.3 in 1955; in the same year it was already being manufactured serially. There is a 10 man crew.

The "Shackleton" M.R.3 differs from its predecessors by the landing gear being retractable in flight. The substantially increased capacity of the fuel tanks provide long range and duration of flight. On the upper fuselage turret, there were mounted two 20 mm "British Hispano" cannons.

On the "Shackleton" M.R.3 are provisions for the crew to rest, which is considered necessary in view of long duration of flight of the aircraft. To search submarines, besides radar sets, the aircraft has: an airborne magnetometer, electronic reconnaissance equipment, sonobuoys, a powerful searchlight, "Autolycus" equipment for detecting submarines operating under [RDP] (РДП) snorkel by the exhaust gases. In all 30 such aircraft were construced, but their production has ceased.

At the end of 1965 the English company Hawker Siddeley began to build a new patrol aircraft with the code designation of HS-801, the prototype for which was the De Havilland "Comet" 4C passenger aircraft (Fig. 5). The HS-801 has "Decca" naviagation system and equipment for the "Loran C" radio naviation system; a Doppler radar set; the ASW21D surveillance radar to detect submarines operating under a snorkel and periscope; an automatic radio direction finder (ADF); means of jamming (ECM); an airborne magnetometer, a powerful searchlight.

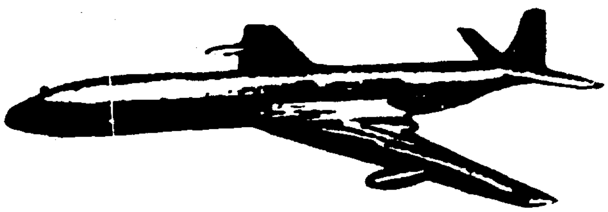

Fig. 5. The De Havilland "Comet" 4C passenger aircraft.

The first flight of the experimental HS-801 "Nimrod" took place on May 23, 1967. The Navy of Great Britain ordered 38 aircraft, the beginning of delivery to the Coastal Command of the Navy was planned in 1969.

The Canadair CL-28 "Argus." A patrol bomber, it is a coastial-based antisubmarine aircraft. The Canadair CL-28 "Argus" has been in the inventory of the Navy of Canada since May 1958 (Fig. 6). This aircraft was construced on the basis of the English series-produced Bristol "Britinnia" 310 aircraft.

Fig. 6. The Canadair CL-28 "Argus" patrol bomber.

Work on the CL-28 project began in April 1954. In 1958, the series-produced CL-28 "Argus" aircraft (military designation CP-107) began to be accepted in the inventory of the naval aviation of Canada. In all 33 "Argus" aircraft were constructed. In 1960 their construction ended.

According to design, the Canadair CL-28 "Argus" is a four-engine all-metal aircraft with a low wing and large fuselage capacity.

In the wings are placed four fuel tanks with a total capacity of 32,676 *l*, which guarantees the aircraft a duration of flight up to 26 h, and a range of up to 6440 km.

Two bomb bays 5.5 m long each are located in the lower part of the fuselage. Furthermore, under the cantilever section of each wing, there are mounts to suspend one missile weighing up to 172[illegible] kg. The maximum weight of ammunition on the aircraft is about 7000 kg.

The navigation equipment of the aircraft includes: the "Loran" system of long-range navigation; an automatic radio direction finder; the "Tacan" short-range radio navigation system; the complex "ANTAC"[1] navigation-piloting instruments and equipment, specially developed for the CL-28; means of radio intelligence and jamming. For the search of submarines and surface ships there are two radar sets. The operation of both sets is synchronized and provides a circular scan of the water's surface. On the aircraft there is an airborne magnetometer, the sensor of which is on a rod behind tail unit, in order to decrease distortions in the magnetometer readings from the influence of the aircraft's electromagnetic field. On the aircraft are used sono and marker buoys. On the aircraft there is a powerful searchlight.

The crew is composed of three pilots, three navigators, two flight engineers and seven equipment operators. With a maximum speed of the aircraft up to 470 kph its cruising speed (the "speed of thrust") in a flight from an airfield to the region where a submarine is detected or is assumed to be, is only 320 kph. Such a speed when conducting operations against atomic submarines is inadequate. The "Argus" has been taken from production, but it is still in the inventory.

The Lockheed P-3A "Orion." The land-based patrol aircraft was intended to perform the following basic missions:

1. patrolling the coastal region of an ocean to detect the approach of sea landings, accompanied by surface vessels and submarines;

2. patrolling in the outlying ocean region from base (airfield) when accompanying the strike units of the navy and vessels, and also

[1]ANTAC - air navigation and tactical air control. The company that developed the ANTAC navigation-piloting complex is Computing Denises of Canada.

when conducting general search of submarines;

3. barrage patrolling on an antisubmarine boundary or another line of observation (blockade, barrier) for the detection, the identification and the attack of penetrating submarines, of surface vessels or of the vessels of the enemy;

4. identification (classification). When obtaining information about the assumed presence of underwater and surface targets in any ocean region, the aircraft should in minimum time arrive at the designated region to establish contact with the target and stay there a long time, observing it or conducting a search of the target. For this, the aircraft should have a high in flight speed from an airfield to an assigned ocean region and a considerable range of operation of the airborne systems to detect surface vessels, but mainly submarines.

By the tactical-technical requirements there was provided an alternate use of the aircraft as an air control post in antisubmarine operations.

In April 1958, Lockheed offered to create a patrol aircraft on the basis of the company series-produced passenger aircraft, the "Electra." The proposal of Lockheed was recognized as the best and the U. S. Navy concluded an agreement with it.

In November 1959 the flight tests of the experimental aircraft were started, and in 1962 the first P-3A "Orion" aircraft was accepted into the inventory of the land-based aviation of the U. S. Navy.

On the whole, from the time of distribution of the tactical-technical requirements (TTT) for the development of the land-based patrol aircraft (1957) to the delivery of part of the first P-3A "Orion" series-produced aircraft (1962), 5 years was required.

In connection with the fact that a large part of the flight of a patrol aircraft is at low altitudes, where with bumpiness dynamic loads increase sharply, the majority of the structural elements of the aircraft was strengthened and the permissible operational overload was brought up to 3.0 (verses 2.5 on the "Electra"), the safety factor up to 1.5, the calculated maximum overload up to 4.5.

The fuselage of the aircraft (Fig. 7) is of semimonocoque design, round and 3.43 m in diameter. The capacity of the pressurized cabin is 195 m^3, which makes it possible to conveniently accomodate in it the crew, search equipment, means of communication and weapons control. The fitted glass area of the front and side walls of the cockpit is 1.86 m^2, which provides a good view for the pilots. The means of destruction are placed in the lower unpressurized forward part of the fuselage and on the mounts under the wings.

Fig. 7. Lockheed P-3A "Orion" land-based patrol aircraft.

The wing at the leading edge has a channel for hot air of the deicer system. The fin and the stabilizer are equipped with an electrical deicing system. At gross flight weight, the aircraft can perform horizontal flight and even gain altitude with two operating engines.

Lockheed developed the "Orion" P-3B and P-3C versions, for which there were provisions for more economical [TVD] (ТВД) turboprop engines in terms of fuel consumption by regenerating the heat of the exhaust gases. The allowed increasing duration and the range of flight of the aircraft.

The flight crew: two pilots, aircraft commander, tactical coordination officer, a radio operator and five operator specialists on the use of the means of submarine search.

The organization of the complex use of various airborne facilities and the training of the decisions of the crew chief for search and destruction of a submarine are the obligation of the tactical coordination officer, who for the first time is introduced into the personnel of the P-3A "Orion" crew.

For detection, identification and destruction of submarines, the P-3A "Orion" has the following means.

Equipment for detecting and determining the position of submarines are: radar sets; "Jezebel" and "Julie" systems, an airborne magnetometer; an ultrashort-wave radio direction finder (the AN/APA-25A), which allows determining instantly the heading to an operating radio station and a jamming station and also their working frequency and pulse-tracking frequency; a device for detecting exhaust gases in the atmosphere from the operating diesels of submarine ("Sniffer" type of equipment); two radar sets (AN/ARC-52 and AN/ARC-84).

Identification is carried out according to the totality of data of all search means. The gross weight of the search equipment of the P-3A "Orion" is about 2.5 t.

The means of annihilating submarines and surface targets are: 3-4 antisubmarine homing torpedoes; depth charges, equipped with conventional explosives; the "Lulu" type atomic depth charges; conventional antisubmarine aerial bombs, mines, missiles of the "air-to-ship" class. The normal weight of the combat load on the aircraft is about 4950 kg; maximum is up to 6800 kg.

On the aircraft there is no defensive armament, but, having jamming means, the crew can create interferences for the

radio-electronic gunsights of fighters, the control systems for missiles of the "ground-to-air" and air-to-air" class.

The basis of the navigation equipment of the aircraft is the AN/APN-42 inertial navigation system with corrections from the magnetic compass. The system delivers the magnetic and true course, the ground speed, the track being passed, the track angle and the coordinates of the position of the aircraft. On the aircraft there is the Doppler AN/APN-122 system. During flights in high northern and southern latitudes (70° and more), for navigation is used the orthodromic coordinate system. In long-range flights is used the airborne system of long-range radio navigation "Loran" AN/APN-70, and also periscopic sextant and the B6 driftmeter.

The tactical system of navigation guarantees the crew a visual (graphic) image of the track and gives out with high accuracy the coordinates of the actual position of the aircraft relative to a fixed point. For this, there is a ground-position indicator (the PT-396/AS), which draws on the plotting-board indicator of the navigator the track of the aircraft, an analogous instrument (the (OA-1768/A/ASA-13) issues data to the pilots on their plotting-board indicator.

All the necessary navigation data are automatically given out to all the posts of the antisubmarine warfare operators.

Communication on the aircraft is carried out with the help of two transceiving radio sets, the AN/ARC-84 and the AN/ARC-52, which are connected into the intra-aircraft intercomm for communication between the members of the crew, which allows every crew member to listen to any receiver. Both radio sets are connected to airborne teletype.

On the aircraft there is an automatic pilot and special flight instruments, which make it possible for the crew with a high degree of accuracy to maintain an assigned condition during flights at any time of the day, under clear and severe weather conditions.

At a take-off weight of 56,700 kg, the take-off run is 1140 m. The take-off speed is 240 kph.

The aircraft has been designed for operation at airfields with a hard surface. The landing distance under normal conditions when the landing weight of the aircraft is 41,277 kg is 520 m, and the landing run after landing is 410 m.

Taking into account the considerable duration of flight (up to 17 h), the aircraft in order to rest the crew is equipped with air-conditioned compartments.

It has been reported that in the beginning of 1967 Lockheed had an order for 297 P-3 "Orion" aircrafts.

Breguet 1150 "Atlantic." The Breguet 1150 "Atlantic" is a twin-engined aircraft, with low wing and a capacious fuselage typical in shape for the majority of medium range passenger aircraft (Fig. 8).

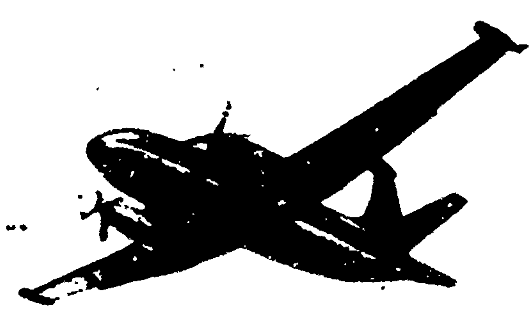

Fig. 8. Breguet 1150 "Atlantic" land-based antisubmarine aircraft.

In the aircraft design laminated panels with honeycomb filler are widely used, and principles of construction which are safe under failure conditions, have been established.

The fuselage in its cross section is represented by two circumferences being intersected. Along the line of their intersection

the floor divides the fuselage into upper and lower halves. In the large part the upper half of the fuselage is pressurized. There, the 12 man aircrew, and also the equipment and instruments for search and identification of surface and submarine targets, instruments and equipment for air navigation and aircraft and weapon control are accommodated.

The cockpit is located at the forward part of the upper half of the fuselage. In the cockpit the two pilots and the observer are accommodated. Behind the cockpit is located the compartment for the equipment and instruments. There, the electronic equipment operators and radio operator are accommodated. Behind the equipment compartment are located the compartments for crew rest with berths, a kitchen, a table and latrine.

Much of the electronic equipment for the aircraft is supplied by the USA. The complex of equipment for search and identification of submarine targets available on the Breguet 1150 "Atlantic" is similar to the equipment installed in the Lockheed P-3A "Orion." It includes: two simultaneously operating search radars, which provide 360° scan of a water surface; detection equipment of gases in the air from operating engines of diesel submarines; sonobuoys; an airborne magnetometer; radio intelligence and jamming sets.

Target identification is carried out by the totality of information from all the means of search, available on the aircraft with regard for the operational-tactical situation in the region of search.

The bomb bay is 9 m long, divided into four sections, and is located in the lower unpressurized part of the fuselage. The combat load of the aircraft can include in various combinations all the standard aerial bombs accepted by the NATO Joint Armed Forces; American and French electro-acoustic torpedoes LK-4, depth charges by NATO, or American MK44 antisubmarine torpedoes.

Under the right and left planes there is one pylon each, onto which rockets with armor-piercing heads of type HVAR (high velocity aircraft rockets) can be hung.

The aircraft design provided a power reserve of the propulsion system which makes it possible to perform a flight in the cruising mode with one operating engine.

For navigation there are used the "Loran C" system of long-range radio navigation; the "Tacan" system of short-range tactical navigation; a navigation indicator (the PH-1); an automatic radio direction finder (AD); radar sets.

Navigation equipment installed on the aircraft provides the possibility for flights at anytime of day in clear and severe weather conditions, to automatically determine the actual position of the aircraft at any moment of flight.

As has been reported in the press, for the Navy of France 40 aircraft were ordered and for the Navy of the Federal Republic of Germany - 20. At the beginning of 1967 in the combat training of the naval aviation of France and the FRG there were used 8 aircraft each.

Despite the fact that the English company Avro took part in the development of the "Atlantic," the Navy of Great Britain refused to accept it in the inventory.

Carrier-Based Antisubmarine Aircraft

The Grumman S2F-3 (S-2D) "Tracker." The first flight of the experimental Grumman XS2F-1 of the prototype S2F-3 (S-2D) "Tracker" was in 1952. In 1953 the S2F-1 was accepted into the inventory of the U. S. Navy, and, henceforth, its modifications are a unique type of an antisubmarine aircraft of the carrier-based aviation of the U. S. Navy. Toward the end of 1964 the company produced about 7[illegible]

aircraft of these types, and their production continued until the end of 1965.

Besides the U. S. Navy, Grumman supplied S2F aircraft to the navies of the Netherlands, Japan, Italy, Brazil and Australia. In these countries the S2F was used basically as a coastal-based patrol (antisubmarine) aircraft. A Canadian company[1] according to the license acquired by Grumman built the CS2F-1 and CS2F-2 for the Navy of Canada. In all about 100 aircraft were manufactured.

In terms of structural arrangement all versions of the aircraft, and especially the S2F-3 (S-2D) "Tracker," are piston twin-engined, all-metal monoplanes with a high wing and upward folding (as a tent) cantilevers (Fig. 9).

Fig. 9. The Grumman S-2D "Tracker" carrier-based antisubmarine aircraft.

The aircraft has tricycle retractable landing gear standard for carrier-based aircraft. There is a 4 man crew: two pilots, one of them carries out the duties of a navigator, a radio operator and an operator of the means of submarine search.

On the Grumman S-2D "Tracker," the following equipment and armament for detection, identification and destruction of submarines are installed.

Equipment for detection and determination of the position of submarines: the "Jezebel" and "Julie" systems; an airborne radio direction finder for determining the bearing for an operating radio

[1]De Havilland Aircraft of Canada.

station or a jamming station; a "Sniffer" instrument for detection of exhaust gases in the air of the engines of diesel submarines; an airborne magnetometer, the receiver of which is mounted on a rod, which is let out the back of the tail section of the fuselage; the AN/APS-80 search radar set; a searchlight with luminous intensity 85 million cp, mounted in the right plane, with remote control from the crew cabin.

Target identification is carried out by the totality of information from all the means of search available on the aircraft, and information received from an aircraft carrier with regard to the operational-tactical situation in the region of operations of a carrier-based antisubmarine hunter-killer group.

The means of destruction of submarines: two homing torpoedoes or conventional depth charges, or an atomic depth charge inside the fuselage and on six wing-tip mounts they are able also to suspend torpedoes, depth charges and rockets.

In the crew cabin on the instrument panel a plotting board is installed, on which are automatically reproduced the coordinates of the aircraft and its actual track with the calculation the Doppler correction of the drift angle and of the ground speed; data about the position of a detected target incoming from the computer of the "Julie" system; the positions of passive and active sonobuoys; the position of a target by radar set data; the target blips by the data of the airborne magnetometer; marks of detection of the exhaust gases in the air of the engines of diesel submarines.

At a distance from an aircraft carrier of 370 km, the Grumman S-2D can patrol for 6 h.

The Grumman S-2A coastal-based patrol aircraft has a fuel reserve 50% greater than the S-2D, and can be flown up to 9 h.

The Breguet 1050 "Alizé." The first flights of the experimental

Breguet 1050 "Alizé" were in 1956. In 1959 the first series-produced aircraft of the 75 ordered was accepted into the inventory of the aircraft carrier of the Navy of France.

The Breguet 1050 "Alizé" (Fig. 10) is a three-seater, single-engined, all-metal, carrier-based, antisubmarine low-wing monoplane with upward folding (as a tent) cantilevers.

Fig. 10. Breguet 1050 "Alizé" carrier-based antisubmarine aircraft.

The tricycle landing gear (with a nose wheel) and the tail hook for catching an arrester wire upon landing on the deck of an aircraft carrier retract into the wing center section and the fuselage.

There is a 3 man crew: the pilot, the navigator (he is the operator of the radar set) and the second radio operator.

The "Alizé" is the lightest of the carrier-based antisubmarine aircraft of the capitalist governments: its take-off weight is 8200 kg. The aircraft has five fuel tanks; their total capacity is 2101 *l*, which provides a duration of flight for the aircraft of up to 5 h. With the mounting of an auxiliary tank with a capacity of 475 *l* the duration of flight reaches 7 h 40 min, and the range - about 2500 km.

Inside, in the lower part of the fuselage, the main ammunition is placed: one antisubmarine torpedo or three aerial bombs weighing 160 kg. Besides this, on the bomb racks under the wing center section two aerial bombs weighing 160 or 175 kg can be mounted, and under each cantilever - one SS-11 "Nord" guided missile or three

127-mm unguided missiles. Sonobuoys are located in the front fairings of the under-wing nacelles, to where the landing gear retracts.

The aircraft has a search radar set, the antenna of which is lowered from a shaft in the fuselage. In favorable hydrometeorologic conditions with the help of a radar set a snorkel can be detected and with a very small probability - the periscope of a submarine. To search for submerged submarines the crew can use sonobuoys, the quantity of which is limited on the aircraft. In terms of its combat capabilities, the aircraft is obsolete and can only be used for conducting warfare with diesel submarines.

The Fairey "Gannet." The Fairey "Gannet" A.S.Mk4 since 1956 has been in the inventory of English aircraft carriers and was manufactured serially (Fig. 11). In 1961-1962, "Gannet" A.S.Mk6 and A.S.Mk7, which differed from the A.S.Mk4 in electronic equipment were accepted into the inventory of aircraft carriers.

Fig. 11. The Fairey "Gannet" A.S. carrier-based antisubmarine aircraft.

Besides the Navy of Great Britain, the "Gannet" antisubmarine aircraft was supplied by Fairey to Australia, where they were used on the "Melbourne" aircraft carrier, and to FRG and Indonesia, where they were used by coastal airfields.

English naval specialists considered that the carrier-based "Gannet" antisubmarine aircraft, in terms of the level of the technical superiority of its search equipment (radar set and 10 sonobuoys), could still be used for conflict with diesel submarines. But on these aircraft, because of the limited capacity of the fuselage and

of the impossibility of increasing the flight weight of the aircraft, the installation of new (and heavier) search equipment and armament for warfare with atomic submarines was excluded. In the beginning of the Sixties the delivery of the "Gannet" A.S.Mk6 and A.S.Mk7 for the Navy of Great Britain by Fairey was discontinued. The "Gannet" antisubmarine aircraft, available in the inventory of aircraft carriers, were reconstructed into carrier-based aircraft of long-range radar detection - the "Gannet" AEW Mk3. For conflict with submarines with solution of the problems of antisubmarine protection for ship formations and convoys while crossing a sea, the Admiralty chose to use antisubmarine helicopters.

Basic tactical flight data of land-based (patrol) and carrier-based antisubmarine aircraft, which are in the inventory of some capitalist countries, is given in Appendix 1.

The Antisubmarine Helicopters Utilized by Aircraft Carriers

The Sikorsky SH-3A "Sea King." The all-weather hunter-killer SH-3A "Sea King" amphibian helicopter is in the inventory of the antisubmarine aircraft carrier of the U. S. Navy (Fig. 12). The crew consists of the pilot and copilot and two operators, who operate the sonar. One of the operators at the same time is also the aircraft radio operator.

Fig. 12. The Sikorsky SH-3A "Sea King" antisubmarine helicopter.

The fuselage is all-metal semimonocoque. To decrease the overall dimensions of the helicopter during storage in the hanger of an aircraft carrier, the tail section of the helicopter can be turned and clamped to the fuselage, as a result of which the overall length of the helicopter is diminished from 16.7 to 14.2 m. Behind the cockpit an instrument section 8.96 × 1.92 × 1.95 m in dimension is located where the sonar is situated and the operator are found. There, a winch with a load capacity of 272 kg is found, which can be used for rescue operations and during landing, when landing (setting down) the helicopter is impossible, or is undesirable.

The lower section of the fuselage of the helicopter has contours and flare in profile as seaplanes of the boat type, which provides seaworthiness, reduces spray when taxiing and provides sufficiently good stability in a class 3 sea condition. According to the many years of observations in various regions of the Atlantic, Pacific and Indian Oceans, it is known that such "lake" conditions (no more than a class 3 condition) are very rare, but with a sea condition more than class 3, the helicopter without its engines operating can overturn. Since 1963, to increase the stability of the floating helicopter inside the front wheel fairings of the landing gear there are rubber balloons, which when landing on the water are automatically inflated with air.

The helicopter is provided with equipment for external suspension under the fuselage and transportation of cargo weighing up to 2700 kg and for towing small vessels.

The rotor is metallic and five-bladed with a diameter of 18.9 m. The blades are interchangeable. The area covered by rotor is 280.5 m^2. The rotor revolves at a constant rate of 200 r/min.

The landing gear consists of two struts with two wheels on each, which are retractable into special nacelles, and non-retractable oriented tail wheel.

The fuel is placed in two groups of bulletproof tanks with an overall capacity of 2600 l, mounted under the floor of the cargo compartment.

The helicopter's equipment includes an automatic pilot; an automatic course, pitch and roll stabilization system for horizontal flight and hovering; an automatic device for the transition into the hovering mode; an APN-117 radar altimeter; an AN/APN-97A Doppler radar set, intended for flights at low altitude, at night and under severe weather conditions, the Bendix AN/AQS-10 sonar, with the help of which under favorable hydrological conditions a submerged moving submarine can be detected at a range of up to 5 km, and according to some sources - 10 km. Sonar is connected to radio altimeter and the Doppler radar set, which provides automatic holding of an altitude with hydrophone lowered into the water.

As was reported in the press, into the inventory will enter a new version of the Sikorsky SH-3D "Sea King" helicopter with two turboprop engines of 1400 bph each and improved sonar. Possibly, the SH-3D will gradually replace the SH-3A helicopters in the inventory.

A substantial increase in the combat capabilities of antisubmarine helicopters, especially in relationship to the increase in range and duration of patrolling, in which helicopters are inferior to antisubmarine aircraft, can be achieved by the aerial refueling of the helicopters. Technology and the means of the aerial refueling of a helicopter are being mastered in the USA since the beginning of 1966.

The Westland "Wessex" H.A.S.1. The carrier-based antisubmarine helicopter (Fig. 13) is in the inventory of the aircraft carriers of Great Britain and of Australia. The "Wessex" is the evolution of the American Sikorsky Sh-34 helicopter. The "Wessex" helicopters are being manufactured serially by Westland.

Fig. 13. The Westland "Wessex" H.A.S.1 carrier-based antisubmarine helicopter.

The crew consists of 4 men, including two pilots, an observer (navigator) and the sonar operator.

The fuselage is all-metal. In back of the cockpit is a spacious cargo section measuring 4.04 × 1.83 × 1.6 m, where the sonarman, the sonar and the winch for lowering the hydrophone are situated. The fin with tail rotor is fastened on hinges and during the storage of the helicopter in the hangar of an aircraft carrier can be turned 180° and pressed to the fuselage.

Fuel is in two groups of tanks with an overall capacity of 1410 l, positioned under the floor of the cargo compartment. A mounting is provided for two under-wing fuel tanks along the sides of the fuselage with a capacity of 454 l each.

The landing gear is non-retractable and consists of two front wheels and a tail oriented wheel, reinforced by shock struts.

The helicopter control is double booster. In the control system the equipment of automatic stabilization of the helicopter in flight is turned on by three shafts of the "Louis Newmark (Lear)" Mk19 type.

Equipment. The helicopter has Ryon APN-97A Doppler radar set, which allows with a high degree of accuracy, the determining of the ground speed and the flight altitude. The sonar, installed in the helicopter, under favorable hydrometeorologic conditions (no more than a class 3 sea condition) allegedly has the capability to detect submarines at a range of 5-10 km, i.e., like the sonar installed in the SH-3A "Sea King."

Based on material of the foreign press it is known that in series-produced production are the Westland "Wessex" antisubmarine helicopters with the Napier "Gazelle" NGa 162 turboprop engine with 1540 hp; 27 such machines are also ordered for the fleet of Australia. There was reported the output of the new version under the trademark of "Wessex" H.A.S.3 with a Napier "Gazelle" NGa 162 Mk165 engine with 1850 hp.

In the English press it was reported that at the plants of Westland, the Sikorsky SH-3K antisubmarine helicopters (a take-off weight of 8 t) are being built, onto which are being installed two English Bristol-Siddley-Gnome turboprop engines with 1400 hp each. The rotor is 18.9 m in diameter. On the helicopter English electronics will be used. As is proposed, the helicopter will have a speed of up to 260 kph. It has been planned since 1969 to replace all "Wessex" antisubmarine helicopters in the inventory with helicopters of type SH-3K.

The Sud-Aviation SA-3210 "Super Frelon." The SA-3210 "Super Frelon" amphibian helicopter is constructed by a standard scheme with a single rotor and a single tail rotor.

The crew of the helicopter is composed of two pilots, and operator and a radio operator.

The fuselage is all-metal semimonocoque with contours and the shape of the frames characteristic for boat seaplanes. The lower section of the fuselage (below the floor of the cargo compartment) is divided by water-tight walls by which unsinkability of the helicopter is reached with holes in the bottom. The seaworthiness of the helicopter is calculated not only for safeguarding in the case of a forced landing at sea, but also for daily operation from the water's surface. The cargo compartment has a capacity of about 22 m^3. Flexible fuel tanks with a capacity of 3560 *l* are placed under the floor of the cargo compartment.

The use of three engines with a driving mechanism for a single transmission increases the reliability of the helicopter, because it can fly even with two operating engines. The maximum power of the power system is 3 × 1300 hp. The rotor is six-bladed with a diameter of 18.9 m (the propelling area of 280 m^2); the all-metal blades with a hinge bracing are interchangeable and folding. The tail rotor is metal five-bladed with diameter of 1.6 m. For the convenience of storage of the helicopter in the hangar of an aircraft carrier, the tail boom together with the rotor is hydraulically tilted to the side and is pressed to the fuselage on the right side.

Equipment includes an automatic pilot, a Doppler radar set and navigation system, which allow flying at night and under severe weather conditions over the sea at a low altitude. There is sonar for the search of underwater targets.

Helicopters for Use From Antisubmarine Ships

The Gyrodyne QH-50C (Fig. 14) is a light helicopter with two coaxial rotors 6.1 m in diameter. One revolves clockwise and the other counterclockwise, which keeps the helicopter on course without a tail rotor, as is required on single-rotor helicopters.

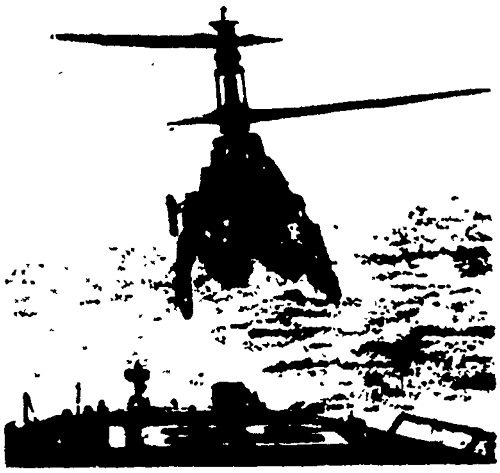

Fig. 14. Pilotless radio-controlled helicopter of the DASH system Gyrodyne QH-50C.

Fuselage. The structural base of the helicopter is an open framework (without a skin) welded from thin-walled metallic tubes on which are mounted the power system, fuel tanks, rotor drive, control equipment and antisubmarine weapons holders. The helicopter has ski landing gear.

The helicopter equipment includes: control signal receiver for signals sent from a ship control point; decoding equipment; electronic equipment, which manufactures the executive flight control and torpedo launching commands: the power drives of the controls and the mechanism for dropping torpedoes.

In 1964 Gyrodyne developed a new modification of the pilotless radio-controlled helicopter QH-50D, which, outwardly is no different from the QH-50C, has a tactical flight radius of 40-65 km, flight duration 1 h 30 m (instead of 1 h); useful load 545 kg (instead of 410 kg). At the end of 1965 four QH-50D were presented by the firm to a customer (U. S. Navy) for tests.

The QH-50D has a more powerful motor, the Boeing T50-130-10 with a take-off power of 330 hp, and the fuel tank capacity has been increased to 196 l (instead of the 136 l on the QH-50C).

The QH-50D employs a Doppler radar system, which will be used for programmed flights. Furthermore, the QH-50D can take a large deep-water sonobuoy or container with an RGP (sonobuoy). The armament of the QH-50D is one homing antisubmarine Mk.46 torpedo or two antisubmarine Mk.44 torpedoes.

In 1967 the budget of the U. S. Navy allocated 19 million dollars to acquire DASH helicopters of the QH-50D type (the draft budget of the Navy had planned on 44 million dollars).

As experience has shown, the flight of a QH-50C from the deck of a ship is rather simple, but landing on a limited area on the deck of a rolling ship presents severe difficulties, which fairly often lead to breakdowns and loss of helicopters. According to data from Gyrodyne, after four years of operation of the DASH system for every thousand hours of flight there are 40 helicopter losses. After several years of operating the pilotless QH-50 233 helicopters broke up. As it was reported in the press,[1] the USAF acknowledged that investments on the building of these helicopters were unjustified and ended their production.

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[1]"Interavia Air Lefter", dec. H, 1968.

"Wasp" A.S.1. A manned helicopter for use with surface craft by order of the English Admiralty was developed by Westland Ltd. on a base of the series-produced "Scout" helicopter (Fig. 15). During September, 1961, the Admirality concluded with the firm an agreement to deliver to the English fleet a considerable number of anti-submarine "Wasp" helicopters.

Fig. 15. Westland "Wasp" H.A.S.1. antisubmarine helicopter for use from destroyer and destroyer escort vessels.

The new antisubmarine helicopter differs from its prototype mainly by the fact that for convenience of storage the tail boom with the tail rotor is on the side, and also the landing gear facilitates landing on the small aft area of destroyers, destroyer escort vessels and frigates.

Besides the basic tactical assignments of the Wasp helicopter as a weapons carrier to destroy submarines, guided from sonar data of a ship, it must make an independent search for submarines in a limited region, for which there are RGB on it; carry out reconnaissance over ice and if necessary transfer personnel from ship to ship or from ship to shore and back.

The first flight of the antisubmarine "Wasp" H.A.S.1. helicopter was in 1962. Delivery to the English fleet of "Wasp" H.A.S.1. helicopters was begun in 1963.

The helicopter crew is 2 men: pilot and operator.

Fuselage - all-metal from aluminium alloy poured under pressure; it consists of two sections. The front section includes the cockpit, a compartment for fuel tanks and a rear stressed partition for butting against the rear section. The stern part of the fuselage is a cone-shaped tail boom ending in a keel on the left of which is attached the mechanism for the tail rotor. On the right side of the keel is a horizontal stabilizer. Landing gear - nonretractable four-wheeled.

The rotor is four-bladed, the blades are metal and fold lengthwise along the tail girder. The tail rotor is a two-bladed metal piece.

Fuel is placed in three flexible cells with an overall capacity of 706 l interconnected and fixed in the front section of the fuselage after the pilot's compartment and below the rotor.

The basic tactical flight data of antisubmarine helicopters are given in Appendix 2.

Antisubmarine Airships

During the First World War the navies of Great Britain, Germany, France, Italy and the USA used a considerable number of airships. They were used for reconnaissance of mine fields, ship convoys and submarine search.

In the Second World War as a result of large development of aviation the role of the airship diminished. Nevertheless the USA continued to build them. At the beginning of the war the airship service of the U. S. Navy had eight nonrigid airships in all, and at the end in 1944 there were already about 200. For the

entire period of the war airships escorted 89,000 ships and completed 55,900 combat missions.

Foreign war specialists consider that along with aircraft and helicopters airships can be used also to carry means for searching out and destroying submarines. The effectiveness of airships in combat against underwater vessels, as was indicated in the press, is because of their long endurance - more than 200 h, the ability to stay in the air over an assigned place and to fly at speeds up to 150 km/h. Airships possessing a large lifting capacity are able to take on-board powerful sonar equipment and other search means, and also effective means for destroying submarines.

After the end of the Second World War the USA began development of new types of military airships. The first postwar American airship SZG-4 (Fig. 16) in comparison with those of the Second World War was heavier, had a light aluminum framework covered over by a nylon skin.

Fig. 16. The first post-war anti-submarine airship SZG-4 (USA).

In 1951 appeared airships of the ZPG-1 type (Fig. 17) about 37,000 m^3 in volume. Their envelope was filled with helium. The airships carried two Wright 1300-2A "Cyclone" engines, which drove

two tracter three-blade reversible propellers with controllable pitch. Because of a special transmission both propellers could operate from one engine.

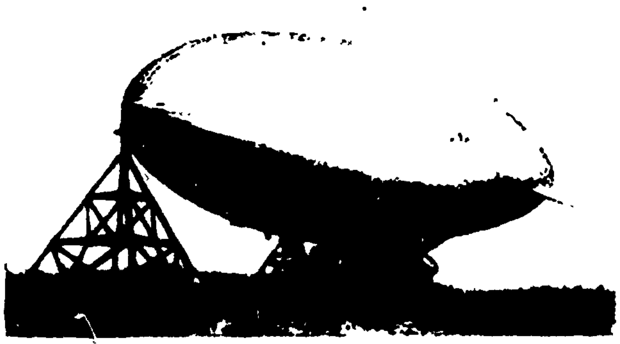

Fig. 17. U. S. Navy airship ZPG-2 and mobile mooring equipment.

The crew of the airship consisted of 14 men. The ground service of the airships was mechanized with the help of special self-propelled mooring devices - "mules" (Fig. 17). The DW-20 mules towed the airship to its start, and after landing into the region of the mooring ground or into a hanger.

In the 1950's, as was noted in the press, airships of the type ZPG-2 were built, which were made in two variants: for long-range radar patrol and antisubmarine defense. They differed from one another only in equipment and in the composition of the crew. The length of the airships of both types were about 104 m, height [illegible] m, diameter 23.5, volume of envelope 28,300 m^3, useful load 5.4 t, maximum speed 110 km/h.

Airships of the ZPG-2 type could be fueled in the air, take on rations and combat supplies from a tanker or aircraft carrier and, if is necessary, even change crews.

In the cabin of a crew was installed an automatic pilot especially developed for the airship. The radar unit of the airship allegedly could detect surface targets at up to 150-180 km.

During tests of the ZPG-2 an endurance of 264 h was achieved. During this time the airship flew a distance of about 15,000 km.

In 1959 Goodyear finished building the ZPG-3 with a volume of 42,500 m^3. The useful load of the airship was 10.5 t, and the crew was 21 men. The rated maximum endurance of this airship was about 300 h, flying range up to 17,000 km, and greatest speed 145 km/h. The airship was equipped with an AN/SPS-70 radar unit.

At the end of 1959 the ZPG-3 underwent flight tests in the region of the North Pole, and after this it was included in the first lighter-than-air squadron of the early-warning service.

In 1961 American command decided to conserve all military antisubmarine airships. However, later it was reported, that the USA was developing a project for an all-metal airship, the SMD-100 (Fig. 18). It has to have a gastight envelope assembled from profiled metal strips and filled with helium. The length of the hull was 177 m, lifting capacity more than 110 t, speed 185 km/h.

Fig. 18. The American all-metal airship SMD-100 (a project).

In 1964 the American firm Aereon by order of the U. S. Navy constructed an experimental model of a three-hull rigid airship, the "Aereon" (Fig. 19).

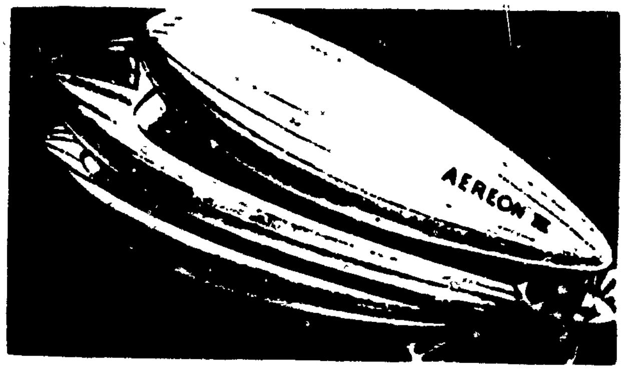

Fig. 19. Experimental three-hull airship of the U. S. Navy "Aereon III."

The "Aereon" has three rigidly connected hulls. It is propelled by a two-blade helicopter-type propeller on the horizontal shaft of the engine on the stern of the middle hull.

The "Aereon" partially realizes the idea about controlling an airship in the vertical plane by heating the filler gas (carrier gas) with the heat of the engines as proposed by K. E. Tsiolkovskiy as early as 1892 in his work "The controlled all-metal balloon." By governing the degree of the heating the carrier gas it is possible to change the lift force of an airship without applying ballast.

As the firm proposes, the subsequent model of a three-hull airship will have a length of 240 m and lifting capacity of more than 1300 t. Although the SMD-100 and "Aereon" type airships are designed as military transport vehicles, they can be used even for antisubmarine defense.

A serious push in the development of airships is the possibility of equipping them with atomic engines. An atomic airship will be able to load about 150 t and deliver it practically any distance with a speed of more than 150 km/h.

* * *

Operational and Tactical Requirements for Antisubmarine Aircraft and Helicopters

For the last several years the foreign and in particular the American press widely and comprehensively discussed the question about the kind of aircraft necessary in the makeup of forces to combat contemporary atomic underwater vessels today and in the near future. The controversy over the future of carrier-based antisubmarine aircraft was especially sharp. Should further carrier-based antisubmarine aircraft of the usual type be built to replace the "Trackers," had the time come to replace them by helicopters as had already been done in the English fleet? But perhaps a transition should be forced to VTOL aircraft.

The American press has published itself a general outline of the proposed development by the U. S. Navy of air resources for antisubmarine warfare (Fig. 20).

American specialists assert that the possibility of fulfilling the planned program of development of U. S. antisubmarine air resources is based on practical factors:

1) the rapid development of science and technology, including aerohydrodynamics and engine construction, structural materials and electronics;

2) the huge span of scientific research and development (R and D); the presence of well-developed department and company scientific research centers and laboratories; broad attraction of universities and technical colleges to scientific R and D in the area of antisubmarine warfare;

3) the high level of development, strength and practical promise of further expansion and improvement of production in undertakings of the aviation industry and its many attending branches of industry of the USA.

For the last ten years the greatest attention in the USA, France, Great Britain and the FRG has been given to the creation of coastal-based antisubmarine aircraft.

Coastal-based patrol antisubmarine aircraft search out independently and in conjunction with other antisubmarine forces and stationary search and identification facilitates submarines on antisubmarine lines and in open regions of the world ocean. Furthermore, such aircraft, as American specialists consider, can be used as an air command point in antisubmarine operations and as a starting point for future means of destroying submarines. Operational and tactical requirements for such aircraft are inconsistant, but on the whole it should possess at least the following:

1. Considerable flight range, in order that acting from coastal and insular airfields, they can search out and destroy submarines on antisubmarine lines, and also in any region of the world ocean.

2. Capability for long (3-4 days) patrolling in an assigned region of the ocean or on an antisubmarine line.

3. As high a maximum horizontal flight speed as possible in order that when taking off at an alarm, it quickly reaches the region where the underwater target has been detected, and the most advantageous minimum flight speed for prolonged patrolling.

4. Capability of flying at altitudes more than 8000-9000 m in order to achieve the maximum "thrust speed" and at the same time in flights at low altitude have the most advantageous speed which guarantees a prolonged search.

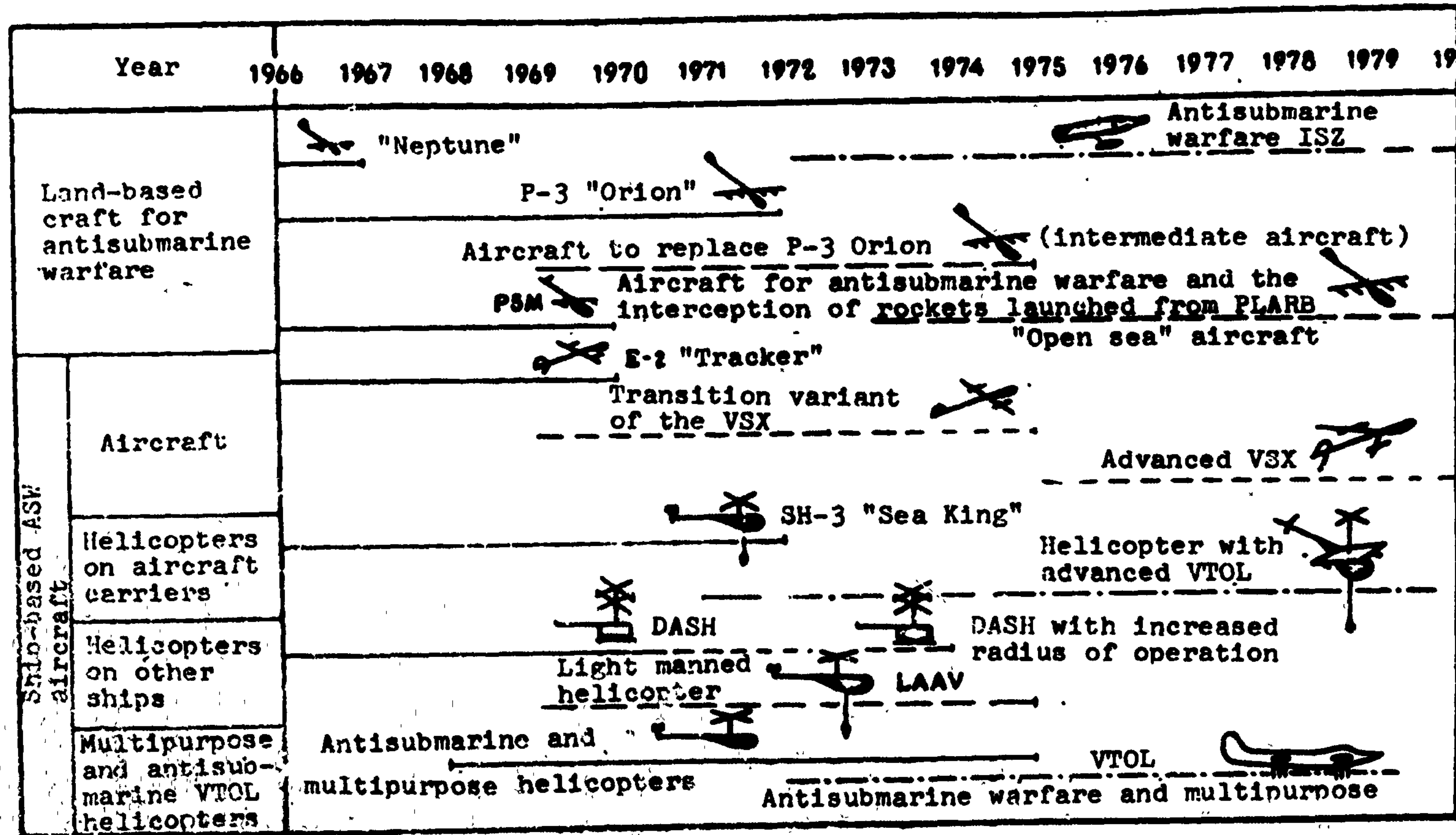

Fig. 20. General outline of the development of air resources of antisubmarine defense.

5. Computer-automated complex of various facilities for searching out, identification and destruction of submarines running underwater, under periscope and snorkel.

6. Considerable useful load capacity in order, except for the search facilities, to carry sufficient ammunition for it to be highly probable that the forces of one aircraft can destroy a discovered submarine.

One can assume that the future land-based antisubmarine aircraft for prolonged patrolling will have a flight weight and useful load capacity which are not inferior to the heavy military transport aircraft of the C-141 and even C-5A type.

7. Good controllability and maneuverability while patrolling at low altitudes and the most advantageous speed.

8. Capability of taking off from improved unpaved airfields - nearly one of the most important requirements for promising heavy land-based antisubmarine aircraft.

9. Favorable work and rest conditions for the crew in flight during prolonged patrolling.

Almost all the above operational and tactical requirements for land-based antisubmarine aircraft are applicable to seaplanes with a similar destination and for carrier-based antisubmarine aircraft with consideration of limitations connected with conditions of operating the latter on an aircraft carrier.

As it is possible to judge from the basic tendencies characteristic of the development of carrier-based manned antisubmarine helicopters in recent years, operational and tactical requirements on it have reduced to the following:

1. Universality, i.e., combining in one piece of equipment the capabilities for search, detection, identification and destruction of an underwater target.

2. Capability for combat action both during the day and at night, under simple and complex hydrometeorological conditions in prolonged flights over water. For this it is considered necessary the helicopter have an automatized piloting system for all flight conditions.

3. Load capacity and fuselage capacity should allow it to carry a searching and sighting system, communications facilities and weapons of destruction, and also the possibility of creating suitable conditions for the work of the crew which would not lower its efficiency in prolonged flights at low alittudes over water, usually in conditions of bumpy air.

4. The helicopter should possess a flight range allowing a prolonged submarine search. In the solution to the last problem the considerable possibilities of increasing endurance and range of antisubmarine helicopters open with refueling in flight from tanker aircraft, which can be based on coastal airfields and aircraft carriers.

5. As great as possible speed a flight, which approaches the speed of contemporary carrier-based antisubmarine aircraft.

6. Capability of landing and taking off on water.

7. Besides sonar, a helicopter should have also other (built on another physical basis) means of search and identification of submarines, the complex utilization of which should be computer-automated, as is done for land-based and carrier-based antisubmarine aircraft.

On existing antisubmarine helicopters, as on antisubmarine aircraft, there is no airborne defensive armament, and none is proposed for the future. In the opinion of naval specialists of the USA, antisubmarine aviation of the NATO countries will act basically over the ocean and at low altitudes in regions where countermeasures by enemy fighters are highly improbable.

Experience in the operation of helicopters of the DASH system with consideration of the properties and capabilities with ship SQS-26 sonar equipment in the USA determined the new requirements on helicopters for the armament of antisubmarine ships.

Under complex conditions of combat and hydrometeorological situations a ship will not always be able to receive upon its deck a radio-controlled helicopter, which has expended its ordnance, and the craft will be lost, which will sharply lower the combat capabilities of the antisubmarine ship. Therefore specialists of the U. S. Navy consider that on antisubmarine ships it is more advantageous to use small light, but manned helicopters of the MASH or LAAV type.[1]

The capabilities of the SQS-26 sonar equipment, which is installed on all destroyer escort vessels of a new type[2] being built in the USA are the following.

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[1]LAAV light airborne ASW Vehicle - light manned antisubmarine helicopters.

[2]A new large escort ship with a displacement of 2624 t; antisubmarine armament; ASROC, DASH and antisubmarine torpedoes (Jane's Fighting Ships" 1965-1966).

The SQS-26 sonar equipment can reveal a submarine in the convergence zone[1] 50-55 km from the ship (Fig. 21). Around the carrier-ship of the SQS-26 it is possible to designate a second zone (radius up to 23 km), within the limits of which the acoustic equipment can directly detect submarines. Between the zone of convergence and the zone of straight action there is an extensive shadow zone where a ship cannot neither directly detect submarines, or observe submarines discovered earlier in the zone of convergence, and that means ASROC and DASH helicopters must be used.

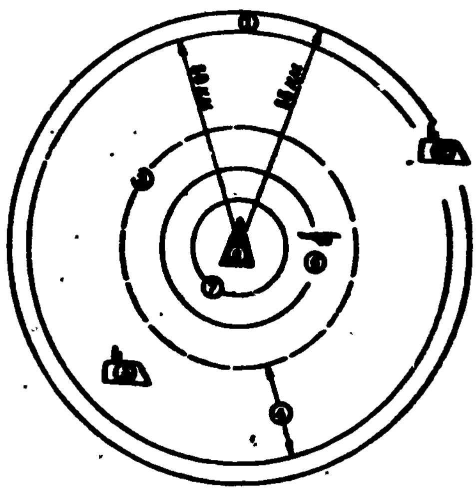


Fig. 21. Zones of range and means of detecting a submarine by SQS-26 sonar equipment: 1 - zone of convergence; 2 - submarine detected by SQS-26 in the zone of convergence; 3 - maximum range of sonar equipment; 4 - shadow; 5 - submarine not detected by SQS-26 in shadow; 6 - maximum distance (up to 18 km) of the DASH helicopter where it can be controlled from the control ship (KP); 7 - distance at which SQS-26 can launch an ASROC; 8 - ship equipped with GAC SQS-26.

[1]Zone of convergence (from the Latin convergo - I approach, I converge) - the zone of convergence of rays of acoustic energy. Acoustic rays propagating in an underwater sonic channel are bent toward the surface of the ocean, where a unique concentration of acoustic energy is observed.

If we allow that with the aid of radio relay means it would be possible to control a DASH beyond the limits of a direct visibility, then from the moment of takeoff in the flight of a helicopter into the region of a target even at a cruising speed of 185 km/h it can reach zones of convergence approximately every 15-20 min. In this time a contemporary atomic submarine, going at a speed of 30 knots (56 km/h), will cover from the point of the first contact 14-18 km. If a helicopter would even detect the submarine, it is highly improbable that at such a large distance from the ship point of radio guidance a helicopter of type QH-50S or QH-50D would be able to close in on the maneuvering target.

For successful utilization of a ship SQS-26 sonar station American specialists consider that aboard the escort ship it is necessary to have a manned antisubmarine helicopter, from which the crew, using information from the ship and the data of their own search equipment, could independently observe and attack the underwater target detected earlier by the ship's sonar in the zone of convergence.

Manned LAAV helicopters have the following tactical and technical requirements: flight speed not less than 320 km/h; holding time over the point of contact with the target in the zone of convergence 1-2 h; high navigation accuracy and time minimum flight. According to the strength of the landing and takeoff area aboard the ship, the take-off weight of the LAAV helicopter should be not more than 1600 kg.

Possible variants of manned LAAV helicopters are the Lockheed XH-51 with a rigid rotor and the FH-100 Killer.

Prospects and Possibilities in the Development of Antisubmarine Aviation of the USA and Other Capitalist Countries

The further improvement of aircraft for various tasks, including antisubmarine aircraft, as was indicated, for example, in "[illegible]"

defining the military technical and financial politics of the U. S. Air Force for 1970-1975, will be achieved because of:

- the substantial improvement in the aerodynamics of aircraft of classical design, helicopters and VTOL aircraft;

- the considerable increase in the specific thrust of gas-turbine engines (GTD);

- the decrease in the specific expenditure of the fuel of GTD;

- the decrease in the relative design weight of aircraft (helicopters) and power devices;

- the wide introduction on aircraft and helicopters of micro-electronics and electronic computers.

Table 1 gives the data which in the opinion of American aviation specialists characterize the actual possible redistribution of the weights of fuel, engines, structures and a useful load in take-off weight for contemporary subsonic long-range transport aircraft and for aircraft proposed for the middle 1970's to 1980's.

Table 1.

Type of aircraft	Weight from take-off weight of aircraft in %			
	fuel	engines	structures and equipment	useful loads
Contemporary long-range transport aircraft	50	10	25	15
First generation of new aircraft (middle 1970's)	45	5	20	30
Second generation of new aircraft (middle 1980's)	40	2	13	45

All three types of aircraft given in the table have an equal take-off weight, equal range and cruising speed of 1000 km/h. If one considers that in the series of parameters tactical and technical requirements for land-based antisubmarine and transport aircraft either coincide or are very close, the data presented in Table 1 can also be attributed to prospective antisubmarine aircraft.

Aircraft Aerodynamics

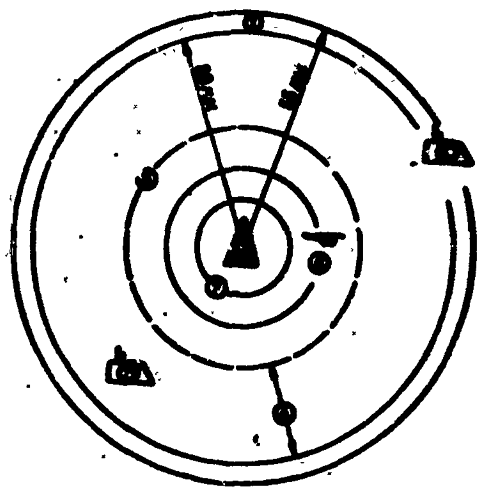
Foreign aviation specialists consider that the flight performance of aircraft of classical design with subsonic speed in the near future will substantially improve preliminarily because of the wide introduction of systems of boundary layer control (UPS) on the aircraft.

The essence of the application of all possible systems of boundary layer control on aircraft is the use of special onboard equipment to regulate the turbulent streamlining of an aircraft in flight, in which on the surface of the wings, fuselage, tail assembly are created vortexes, local condensations and pressure jumps, to make it lamellar (calm) and steady, which will considerably decrease aerodynamic resistance and thereby substantially increase the aerodynamic quality of the aircraft.

Thus, for instance, an aircraft designed for a maximum range at a speed corresponding to Ma = 0.85, which will have a lamellarized wing and tail assembly, can have a 60% greater range than the usual aircraft of equal take-off weight, equal useful load and equal specific fuel consumption for the engines. With a lamellarized fuselage the range can be increased by 15% more.

When using UPS systems which for laminarization blow compressed air on a deflected flap, it is possible to decrease the landing speed of the aircraft by approximately 20-30%, the landing distance 25-40% and the take-off distance 20-25%.

The SQS-26 sonar equipment can reveal a submarine in the convergence zone[1] 50-55 km from the ship (Fig. 21). Around the carrier-ship of the SQS-26 it is possible to designate a second zone (radius up to 23 km), within the limits of which the acoustic equipment can directly detect submarines. Between the zone of convergence and the zone of straight action there is an extensive shadow zone where a ship cannot neither directly detect submarines, or observe submarines discovered earlier in the zone of convergence, and that means ASROC and DASH helicopters must be used.



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When using UPS systems which for laminarization blow compressed air on a deflected flap, it is possible to decrease the landing speed of the aircraft by approximately 20-30%, the landing distance 25-40% and the take-off distance 20-25%.

The USA has investigated the advantages of using flow lamellarization of control systems (ULO) on standard military transport aircraft with a range of 10,200 km and the cruising speed corresponding to Ma = 0.85. The rated useful load is 45,360 kg. The results of comparisons of the data of lamellarized and ordinary aircraft are given in Table 2.

Table 2. The increase in aircraft range with ULO (take-off distance for aircraft is equal).

	The usual aircraft	Aircraft with ULO	
		without thrust augmentation	with augmentation thrust
Take-off weight with useful load 45,360 kg	226,500	231,500	255,000
Distance, km	10,200	15,930	17,700
Increase of distance in comparison with usual aircraft, %		56.4	73.8

VTOL Aircraft

In the USA, Great Britain and other capitalist countries considerable attention has been given to the creation of a different type of VTOL for the needs of the Army, Air Force and Navy.

The creation of VTOL has as its primary goal the exclusion of the dependence of aviation upon airfields with concreted take-off and landing strips. The creation of acceptable types of VTOL of different operational and tactical destination for the Navy would allow building future aircraft carriers of considerably less size and basing aircraft on ships of many classes. The VTOL, while inferior to helicopters in endurance in hovering condition, possess a considerably greater speed of horizontal flight, which is very important even for purposes of antisubmarine combat.

Even in 1960 a special commission of Princeton University made a survey of work in the area of the creation of VTOL. In its conclusions the commission showed that the aircraft industry is on such a level where it is possible to create aircraft of vertical and shortened take-off which correspond operatively to tactical requirements.

Specific attention in the USA and Great Britain is given to the creation of carrier-based VTOL for combat with submarines. By the way, let us recall that in 1972 it already is proposed to have in the armament of aircraft carriers general purpose VTOL and VTOL for antisubmarine warfare (Fig. 26). But in the development of acceptable antisubmarine VTOL for the armament of ships it is necessary to overcome a number of difficulties.

In all cases the power of the engines necessary for flight and landing of VTOL is considerably more than the power necessary for its horizontal flight. Because of this the weight of the power unit in VTOL is more than in usual aircraft, which possesses the same take-off weight, and they lose in the weight of useful load up to 25% in comparison with the usual aircraft of equal weight.

In stability and safety during flight and landing VTOL are still inferior to helicopters. If for the majority of VTOL vertical flight is limited to flight landing and in time does not exceed 5-10 min, then for antisubmarine VTOL in the case of using sonar equipment on them (GAS) - flight in the hovering mode (as a helicopter) should be continued several hours. Nevertheless as foreign specialists consider, by decreasing the specific weight and specific fuel consumption of the engines, the uses of light high-strength structural materials in the near future will make it possible to create acceptable carrier-based antisubmarine VTOL.

Convair has studied the possibilities of developing an aircraft combining the features of the usual seaplane and a craft on an air

cushion. The craft on an air cushion (Fig. 22) is equipped with fans mounted in a wing of relatively small aspect ratio and with peripheral jets.

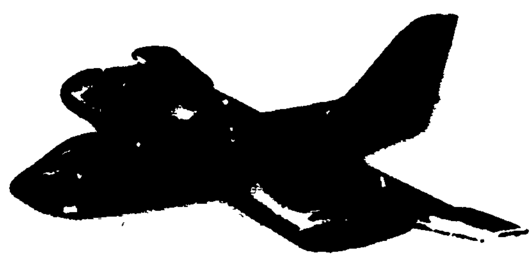

Fig. 22. Aircraft on an air cushion (SVP) Convair.

The take-off maneuver of an aircraft on an air cushion is as follows. First vertical lift to an air cushion at a height of up to 0.9-2.1 m. Then at this height acceleration to gather a speed at which the aerodynamic lift of the wings together with thrust from the wing fans exceeding the weight of the aircraft by approximately 10%. After this the usual gathering of height and further increase in trajectory speed necessary for the particular case. In subsequent flight the SVP is not distinguished from the flight of usual aircraft.

The approach to landing and descent of SVP are carried out as on the usual aircraft. At a low height the lift fans are cut in. On levelling out ground effect gradually increases until, finally, the SVP is supported on the air cushion created by the wing fans. Braking is created by the frontal resistance and reversing the thrust.

The main advantage of SVP in the opinion of the firm and its customers (U. S. Navy and Air Force) is not only the decreased dependence upon airfield, but as Convair confirms, the SVP can take twice the useful load as VTOL of equal take-off weight, but its

thrust-to-weight ratio can be about 0.8 while on VTOL it should be not less than 1.1-12.

The Bureau of Naval Weapons of the USA in 1963 signed with Convair an agreement for conducting studies of SVP. These investigations are being continued and are a program for showing the effectiveness and economy of SVP as antisubmarine aircraft.

Helicopters

As is known, helicopters of classical design are considerably inferior in the speed of horizontal flight to subsonic aircraft of the usual type and to VTOL aircraft. This is because with an increase in speed flight of a helicopter to more than 200 km/h sharply increases the resistance on the rotor and the necessary power of the power system (Fig. 23) to overcome it.

At the same time at large flight speeds helicopters possess low L/D ratio - the unique eff. of aircraft - the ratio of useful lift to the force of head resistance (or the ratio of the weight of the helicopter to the thrust of the power system): the greater the ratio the higher the quality of an aircraft and helicopter. Thus, for instance, at a horizontal flight speed of 200-220 km/h the L/D ratio of a helicopter is approximately 4 times less than for an aircraft (3.5-4 against 12-16), therefore helicopters are considerably inferior to aircraft even in range.

Attempts to improve flight characteristics of helicopters has already led to putting on them a purely aircraft unit - a wing, which makes it possible to increase noticeably the speed of horizontal flight. Thus, the device of a wing on the Soviet Mi-6 helicopter allowed this machine to exceed the international speed record for a flight over a closed route 500 km in length. The average speed was 315.657 km/h. The S-61F helicopter, developed by the American firm Sikorsky, also carried a wing (Fig. 24).

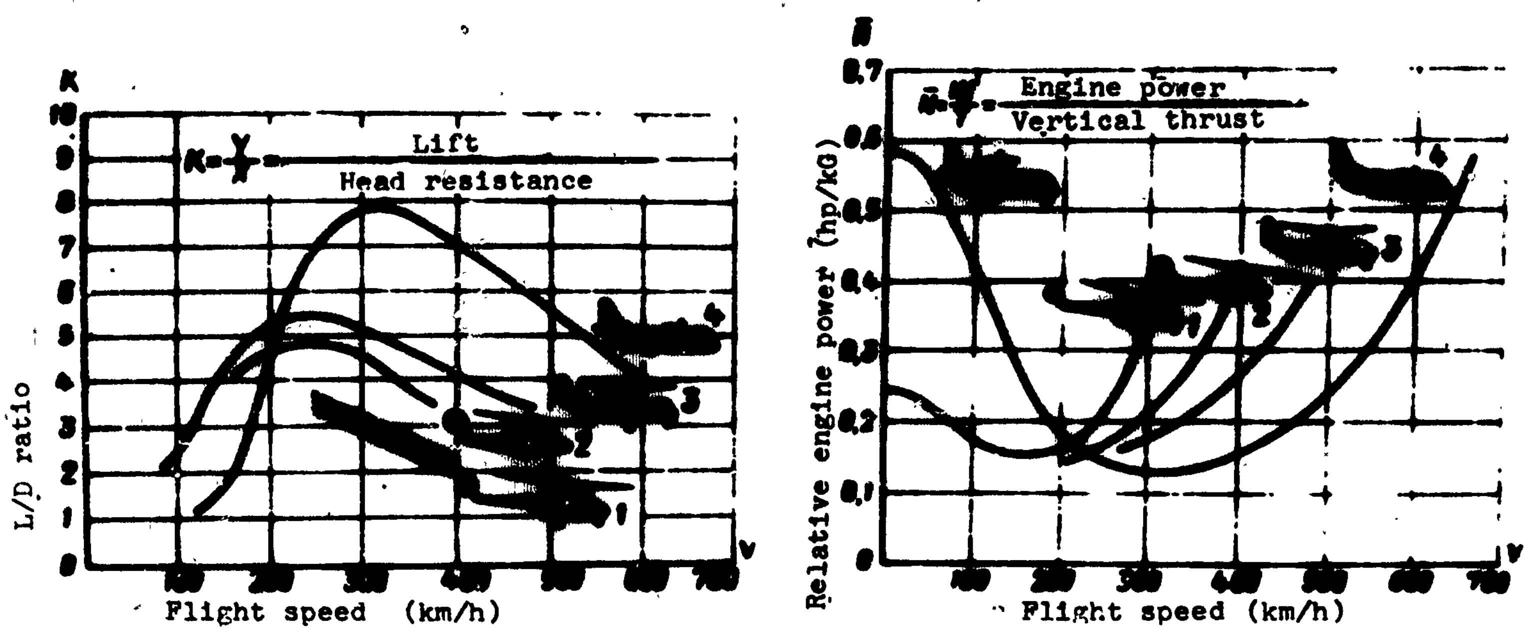

Fig. 23. Ratio of horizontal flight speed of a helicopter and the power necessary for its achievement.

Fig. 24. Sikorsky S-61F helicopter.

Theoretically helicopters with a wing can develop a speed of 600 km/h and higher. To further increase speed and range of a helicopter with a rotor designers consider it necessary to retract the rotor in horizontal flight.

The American firm Lockheed has long operated on the project of a helicopter with a rotor which is retracted in flight. One of recent type is the CL-475 helicopter, which has been given the military designation XH-51A (Fig. 25).

Fig. 25. Lockeed XH-51A helicopter.

In flight with a nonretracted rotor (take-off, landing, low flight speed) the exhaust gases of the engines drive the rotor and in flight with the rotor retracted the engines create only thrust. The rotor is retracted after the helicopter reaches a horizontal flight speed of more than 15) km/h.

The firm has claimed that the maximum speed of the XH-51A will reach 800 km/h; in tests this helicopter showed a speed of 483 km/h.

According to press releases Sikorsky has already developed a design for a helicopter with a wing and folding rotor (flight weight 20 t, useful load 3.6 t). The helicopter carries two turboprop engines, which move a three-blade rotor and tail rotor. In take-off, landing and hovering gases from the engine are directed to the turbine drive of the rotor and tail rotor. In horizontal flight at cruising speed the gases of engines move the thrust fans. The rotor and tail rotor are folded and retracted at a flight speed of 240 km/h. It is proposed that the helicopter will have a cruising flight speed of about 800 km/h, and range up to 950 km.

Helicopters with retracting rotor are the object of specific attention of the U. S. Navy. Possessing a horizontal flight a speed not less than contemporary carrier-based antisubmarine aircraft, antisubmarine helicopters with a retracting rotor will be able to reach rapidly the region of detection of a submarine and to establish contact with it using sonar equipment. At equal flight weights and reserves of fuel, helicopters with retracting rotor will possess considerably greater range than helicopters of classical design.

Aircraft Engines

The most important parameters which characterize the energy and operational qualities of aircraft engines, are: thrust (kgf) or

power (hp); a specific weight (kg/kgf thrust); specific thrust (kgf thrust/kg): specific fuel consumption (kg/kgf.h); overall size (diameter, length); service life and reliability.

Basic trends in improving aircraft engines are considered to be: increase in pressure quality of compressor stages; the increase in calorific intensity of combustion chamber and the use of high-energy propellants; increase in gas temperature before turbine; use of heat regenerators; increase in the by-pass ratio of turbofan engines and additional combustion of fuel in the second loop; substantial decrease in the specific weight and the overall dimensions of engines with a simultaneous increase in power (thrust). Furthermore, increase in physicochemical and mechanical properties of structural materials (metals, plastic and composite materials) used in engine construction has an important value.

As foreign specialists in the area of aircraft engines consider, there are possibilities of increasing the temperature of the gas flow before a turbine from 930° (in contemporary engines) to 1650-1950°C in prospective engines of the next ten years, which will allow increasing the thrust of a gas-turbine engine by more than 2.5 times. In this case the specific fuel consumption can be lowered 20% and more.

The use of a heat regenerator on a turbojet engine allows deep throttling of the engine without increaseing the fuel consumption which is especially important for antisubmarine aircraft during prolonged patrols. Allison has developed a regenerator for the Lockheed C-5A military transports.

To increase the propulsive efficiency the speed of jet of exhaust gases should approach the speed of the aircraft. This has been the attempt in turbofan engines (TVD). On the perimeter of the turbine disc of a turbofan engine are mounted the fan blades.

Air entering the engine is sucked in by the blades of the fan and fed to a jet nozzle, where, mixing with hot gases, it increases the general mass of exhaust (ejecting) gases by a unit of time, which increases the engine thrust.

The thrust of a turbofan engine depends upon the size of the bypass ratio. The latter is the ratio of the mass of air which flows through the fan per unit of time to the mass of air which flow through the combustion chambers of the engine in the same time. The greater the bypass ratio, the greater the thrust of TRDD (ducted-fan engine).

For the Lockheed C-5A General Electric designed the GE-1-16 TRDD with a bypass ratio of 8. With an engine weight of 3250 kg it will develop a thrust of 18,000 kgf.

In the last several years for the development of VTOL with a relatively long endurance in the hovering mode power plants have been designed with one or two TRDD in which the lift fans are extended to the wings and into the fuselage. Such fans in annular ducts can be considered as air stages of a TRDD extended into the wing and fuselage. With the aid of this equipment the bypass ratio can be brought to 6-15, and the vertical thrust in comparison with the thrust "feeding" the TRDD is increased 3-4 times.

Such an engine device has been put on the experimental VTOL XV-5A by the American firms Ryan and General Electric (Fig. 26).

Judging from press publications of the results of scientific research and development of the engine-construction firms of the NATO countries, the next ten years will see the creation of powerful reliable gas-turbine engines of different types with a specific thrust of 20, 30 (kgf thrust/kg) and more.

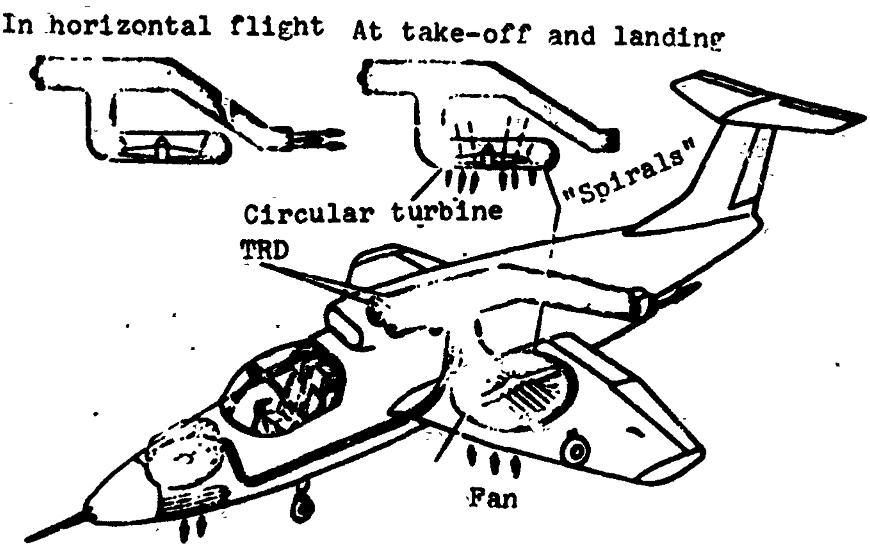

Fig. 26. Ryan VTOL aircraft. Lift fans are extended into the plane and the forward part of the fuselage.

Aircraft Materials

The decrease in the construction weight of the equipment and engines of aircraft (helicopters) is a reserve for increasing their useful load. If one considers that, on to the American press, 1 kg of the weight of an aircraft in 1941 on the average cost $22.00 and in 1965 almost $270.00, then lowering the construction weight of an aircraft and the specific weight of the aircraft engines decreases the expenditure of materials in extremely short supply and noticeably lowers the very high cost of contemporary aircraft.

Lowering the construction weight of the aircraft and engines will be achieved by the use of light and high-strength materials such as titanium and beryllium alloys, low-alloy steels with a high degree of purification from harmful impurities, and glass fiber, plastic and composite materials.

In the construction of civilian aircraft designed by North American requiring a maximum speed corresponding to Mach 2.65, it is proposed to use titanium alloys in almost 74% of the airframe parts by weight, low-alloy steels in 9.2%, noncorrosive steels in 4.1%, nickel alloys in 5.2%, nonmetallic materials in 4.6%, aluminum alloys in 3.3%.

Titanium and its alloys are widely used in jet engines. Their specific strength at high temperatures is higher than that of noncorrosive steel, significantly higher than aluminum alloys and almost two times higher than magnesium alloys. Titanium alloys resist creep well at temperatures up to 540°C over a prolonged time. The advantage of titanium is its high corrosion resistance, but titanium is still considerably more expensive than steel.

The construction of the Sikorsky SN-53A helicopter uses about 612 kg of titanium alloy (6% of the weight of the entire construction), which reduces its weight by 372 kg. It is proposed that in the near future the weight of helicopter parts from titanium alloys be 10-12% of the overall construction weight.

Beryllium and beryllium alloys. The specific weight of beryllium is 1.5 times less than for aluminum. At a temperature within the limits of 25-500°C the specific strength of beryllium exceeds the specific strength of noncorrosive steel by approximately 3-4 times, and aluminum by 3-6 times. The relatively high melting point of beryllium (about 1300°C) allows its prospective use at temperatures up to 850-900°C. The aviation industry of the USA uses beryllium and its alloys basically for the manufacture of aircraft parts which undergo strong aerodynamic and thermal heating, and engine parts.

Composite materials are light metals, plastics, ceramics reinforced by especially strong crystals of other metals, minerals. Composite materials in structure are similar to reinforced concrete.

The strength of the base material upon the introduction of fibers into it increases not because of the high strength of these particles, but because of the fact that the fibers, limiting movements in the matrix (i.e., in the final reinforced, composite material), under a load prevent failure connected with the mechanism of plastic flow. The use of composite materials can lower the construction weight of an aircraft and rockets by 25-35%.

The scientific research group of the English firm Rolls-Royce developed a composite material from light metal reinforced by fibers of silicon oxide. Fibers about 0.025 mm thick, which possess an ultimate tensile strength of 703 kgf/mm^2 thick. The obtained composite material counts from 7800 to 155,000 fibers per cm^2 of the cross section. They consider, that at a temperature of 150°C the ultimate tensile strength of a given material (light alloy) reinforced by fibers of silicon oxide several times exceeds the strength of the usual light alloys.

Especially high strength and rigidity characteristics belong to composite materials from light metals reinforced by fibers of boron. The U. S. Air Force granted AVCO several agreements with an overall cost of $880,000 for the creation of an experimental plant for the production of boron fibers.

Radio Electronics

Abroad work is being carried out in the further increase of the effectiveness of radio electronics equipment intended for anti-submarine aircraft and helicopters. In its development a tendency has been noted to microminiaturization and complexing instruments within the framework of separate radio electronics systems, i.e., creation of equipment which combines the functions of several instruments and which possess small dimensional and weight characteristics. Such an interconnection in most cases rests on the utilization of onboard electronic computers.

According to the estimate of the specialists of the U. S. Air Force, in 1970 more than 40% of aircraft equipment will be made from microelements, standard onboard calculator, which possesses today a volume of about 18,500 cm^3, weight of 40 kg and consumes 142 W, will have a volume of 320 cm^3, weight of about 1.6 kg and will require for its work not more than 8 W. In this case microminiaturization will allow reducing the cost of electronic equipment by approximately 1.5 times and substantially increase its reliability (Table 3).

Table 3. Average unfailing service period of aircraft radio electronics equipment (in relative quantities).

Types of electronic systems	Ultrashort-wave connected radio receiver	Central onboard calculator
System based on tubes prior to 1960	1	1
Standard military systems based on solid circuits	3.7	12.9
System based on solid circuits of high reliability	7.2	242
Microelectronic systems of 1965	57.5	490
Microelectronic systems of 1970	72.5	1290

Organization of Scientific Research and Development in the Area of Antisubmarine Aviation

Prior to 1964 in the USA the numerous problems and tasks in the preparation for combat with submarines were studied by a great many groups, commissions and committees.

For the centralization and radical improvement of preparation for antisubmarine warfare the U. S. Navy created a number of organs among which the following had a specific value and role:

Department for Antisubmarine Programs, at which is laid research on enemy underwater forces, the development of methods of combat utilization of antisubmarine forces and facilities.

Naval Department for the Administration of funds for antisubmarine warfare, one of the basic tasks of which is the manual on basic research in the area of antisubmarine warfare.

Logistical Support Division. In May, 1966, the Department of the Navy passed to a new organization for logistical support under the Navy Chief of Staff. The Navy created a Command for Logistical Support made up of six specialized commands, including the Aircraft Technology Command.

The Aircraft Technology Command is responsible for the design and building of aircraft, their engines, armament (including functions of control over the development of aircraft torpedoes and mines)[1] and also various aircraft airborne and airfield electronic equipment, instruments for astronautics, meteorology and aircraft ship systems.

Everything which refers to the development of antisubmarine techniques of aviation conforms with the administration of antisubmarine programs and the department for the administration of funds for antisubmarine warfare.

Investigations in the interests of development and improvement of special forms of antisubmarine aviation techniques are carried out at the Naval Air Development Center (NADC) in Johnsville (Pennsylvania). The NADC conducted theoretical investigations and development of mathematical models, connected with the application of antisubmarine weapons and scientific R and D in the area of aviation weapons systems and aviation equipment.

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[1]The ordnance systems command is responsible for the development of aircraft armament for antisubmarine warfare (torpedoes, mines).

At China Lake (California) is the Naval Air Facility (NAF) at which is located the Naval Ordance Test Center (NOTC) for scientific research and development.

From 1960 a considerable growth in appropriations for the development of forces and facilities for antisubmarine warfare and antisubmarine aviation has been noted, which is verified by the data given in Table 4.

Table 4. Appropriations for scientific research and development in the area of antisubmarine warfare (in millions of dollars).

Items of expense	Fiscal Year				
	1960/61	1961/62	1962/63	1963/64	1964/65
General scientific development	49.6	39.6	50.6	52.6	58.8
Aviation and aircraft equipment	16.5	18.0	30.6	49.1	65.4
Rockets and rocket equipment	31.2	34.5	38.0	16.0	6.4
Military astronautics	-	0.1	0.3	0.3	0.7
Ships, craft and their equipment	79.8	81.4	114.2	141.2	146.5
Antisubmarine weapons, combat vehicles and their equipment	51.5	42.1	52.4	58.9	76.5
Other armament and equipment	3.7	6.1	5.8	7.6	9.8
Administration and maintenance	16.0	11.1	25.0	24.9	22.4
Totals ..	248.3	239.9	316.9	350.1	386.5

Considerable scientific research and development work in scale and investments in the area of development of antisubmarine aviation techniques also are conducted by many aviation firms by agreement

with the Navy and on their own initiative. One example of such initiative is work being done by Convair in the area of developing an antisubmarine seaplane operating on an air cushion (SVP).

The Aviation Industry of Capitalist Countries

The joint Staffs of America. The aerospace industry (ASI) is the largest branch of industrial production in the USA. The plants, concerns and the scientific research establishments of firms united under an association by June, 1966, employed 1,266,000, including about 215,000 (17%) scientific workers and engineers. Until recently the ASI of the USA was the only supplier of antisubmarine aircraft and helicopters for all NATO countries and allies of the USA against other aggressive blocs.

A determining role in the development of antisubmarine aviation of the USA belongs to the following aviation firms.

Lockheed is an old, basic and large supplier of land-based patrol aircraft for the Navy. Lockheed employs about 75,000 at its aviation plants. Since 1963 it has been supplying the Navy with P-3A Orion patrol plane.

In 1967 Lockheed proposed to build for the Navy the C-5A military transport (flight weight 330 t, useful load depending on distance of flight from 49 to 113 t) as a prototype for developing on its base land-based antisubmarine aircraft for prolonged patrols.

Grumman is the only supplier of carrier-based antisubmarine aircraft for the Navy.

The possibility that the development and building of the carrier-based antisubmarine VSX by tradition will be also given to Grumman is not excluded.

Boeing (at its aircraft factories at Seattle about 5000 are employed; the industrial capabilities of the firm are up to 30 passenger aircraft of the Boeing 727 type per month), as also Lockheed offered the Navy its serial passenger aircraft the Boeing 727M (Fig. 27) for the creation of a land-based patrol (antisubmarine) aircraft on its base.

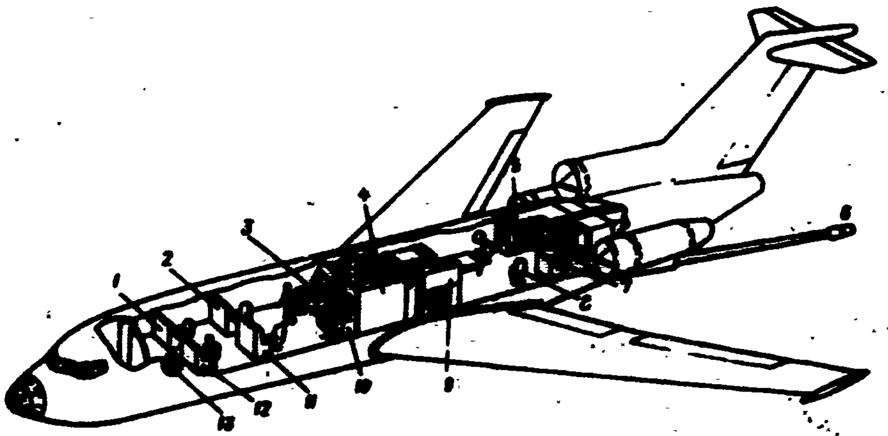

Fig. 27. The Boeing 727M antisubmarine aircraft. 1 - working space of aircraft radio operator; 2 - working space of antisubmarine equipment operator; 3 - panel for receiving radar MAD data; 4 - rock with electronic equipment; 5 - ammunition; 6 - magnetometer (MAD); 7 - working space for armament operator; 8 - working space of tail observer in antisubmarine combat; 9 - power supply control board; 10 - panel for receiving sonobuoy signals in the Julie system; 11 - panel for the receiving sonobuoy signals in the Jezebel system; 12 - working space of navigator; 13 - port for visual observation.

Douglas, large supplier of passenger and military transport aircraft, which possess a large carrying capacity and range also offered the Navy its serial passenger aircraft DC-9 for the creation of a land-based antisubmarine aircraft on its base.

Sikorsky - base supplier of manned antisubmarine helicopters. From 1953 to 1965, i.e., in 12 years, it turned out 3404 helicopters,

of which 1772 were the helicopters of the S-58 type. From 280 to 290 helicopters per year - far from the limit for the Sikorsky helicopter plant.

Gyrodyne - supplier of radio-controlled helicopters, and also the Hiller and Hughes helicopter firms, claiming delivery to the Navy of light manned antisubmarine helicopters of the LAAV type, possess rather high industrial capabilities which allow them to complete the orders of the Navy.

The aviation industry of Great Britain includes several aviation firms (Short, Handley-Page and others) and two large aircraft concerns: BAC (employs 34,265 workers and technical-engineering personnel) and Hawker Siddeley (5 divisions, about 50,000 employees). The latter is the supplier of the HS-801 antisubmarine aircraft for the coastal command. The Westland helicopter concern (6 divisions, 10,000 personnel) is the only supplier of helicopters, including antisubmarine helicopters for the fleet of Great Britain.

The aviation industry of France has several aircraft-engine construction firms, which by the beginning of 1965 employed more than 94,000.

The basic suppliers of antisubmarine (land-based and carrier-based) aircraft is the old Breguet firm. Antisubmarine helicopters are built by Sud Aviation. In industrial capabilities the afore-named firms can completely satisfy the needs of the French fleet on the deliveries of antisubmarine aircraft and helicopters.

FRG. The building of aircraft and helicopters is concentrated at the plants of seven firms employing up to 37,000 men. Two West German firms - Dornier Werke and Ziebel Werke - are taking part in a consortium for the production of the Breguet 1150 Atlantic anti-submarine aircraft. Helicopters are produced at the plants of three firms: VFW, Bolköw, Entwicklungen and Heinkel Flugzeugbau.

The aviation industry of Italy includes about 60 firms united in the consortium AIA (Associazione Industrie Aerospazaet), which at the end of 1965 employed about 15,000 men. Fiat - the largest works in Italy in terms of production of aircraft and engines - developed for the Italian Air Force the G-222 military transport, which is being proposed in a variant of patrol (antisubmarine) aircraft.

The aircraft industry of Japan renewed its activity in 1952 with the repair and servicing of American military aircraft. Today the production of armament for antisubmarine aviation is concentrated with two leading firms.

Mitsubishi. Its aviation plant employs 6300 workers and employees. In the last five years it has been licensed, besides the Lockheed F-104 fighter, to turn out Sikorsky S-55, S-61, S-62, HSS-2 (Sea King) helicopters and has completely supplied the Navy of Japan with antisubmarine helicopters.

Kawasaki has been liscensed to turn out the P-2H Neptune. In accordance with the third plan for building up the armed forces Kawasaki is supplying the Japanese Navy about 70 modified P2V-7 patrol aircraft, of which the first group of 32 was ordered in 1967. Furthermore, during May, 1966, Kawasaki finished building the first model of the domestic PX-S patrol seaplane with four General Electric T-64-1-H-10 2850 hp turboprop engines. It has been proposed that the first several aircraft will begin flights in 1969. After successful tests by the Japanese Navy 22 flying boats were ordered, which the firm will make in 1971-1973.

The large capitalist states, first of all the USA, have an entirely modern aviation industry and large number of generously financed and technically equipped firms and state scientific research and development laboratories, facilities and ranges. In the USA

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and England, France and FRG, Canada and Japan there are sufficient capabilities for developing new types of aircraft with the high tactical flight qualities for warfare against submarines as well as their serial production in the necessary quantities.

CHAPTER II

THE STATUS AND TRENDS IN THE DEVELOPMENT OF AIRBORNE MEASURES FOR COMBATTING SUBMARINES

The measures for combatting submarines include equipment for search, detection, and classification of submarines and measures for their destruction. In the years of World War I, special airborne antisubmarine devices had not been created. The boats were located visually, and regular aircraft armament was used to destroy them.

After the war, the development of antisubmarine measures proceeded extremely slowly, moreover predominantly shipborne sound locator detecting equipment was developed. It was only in 1938 that the English succeeded in creating an active hydroacoustic instrument "Asdic" for the armament of surface ships, which made it possible to detect a submarine by the sound waves reflected from it. The range of action of "Asdic" was insignificant and the accuracy was very low.

During World War II, the first models of sonobuoys and prototypes of the future aeromagnetometers were created for aircraft. During this period, airborne radar played a prominent role, however it could effectively detect submarines only when they were on the surface.

With the advent of atomic submarines in the post-war period, the problem of combatting them became still more acute and difficult. This is explained, in the opinion of foreign specialists, by the fact that atomic submarines, because of certain combat features, in essence turned into a qualitatively new object for aircraft to deal

with, being radically different in respect to conditions of search from the usual diesel submarines armed with torpedo weapons.

The Atomic Submarine as the Object of Airborne Countermeasures

In World War I the time submarines spent continuously under water amounted to 5%, and in the closing years of World War II - 15-25% of their total voyage time.

The prolonged stay of the boats on the surface facilitated their detection by means of airborne radar and led to considerable submarine losses. It was necessary to convert submarines from temporarily submerged or "diving" boats to true submarines, which was done thanks to the application of atomic power plants. As a result, the time spent by modern American nuclear submarines underwater constitutes more than 90% of total voyage time and attains 60 days and more.

The submerged speed of nuclear submarines is one and a half to two times greater than the speed of diesel submarines and at the present time reaches 25-30 knots, and in this case a speed of 60 knots is no longer considered the future limit. The modern nuclear submarine is capable of cruising at depths exceeding 400 m, but in the future foreign experts consider it possible for boats to operate at depths of 1000 m and more. In the opinion of foreign experts, the above-enumerated qualitites of the atomic submarine have sharply increased the capability to operate concealed and have substantially enhanced the capability of avoiding detection and destruction by airborne resources. The great depths of submersion is an important condition for the successful evasion by a submarine of forces and facilities for antisubmarine warfare, because with the increase in the depth the probability of its detection by airborne means is reduced and the "kill time" of the antisubmarine weapon increase, i.e., the time between the moment it is dropped and the moment of its reaching the target.

The use of atomic energy plants opened practically unlimited capabilities for submarines for increasing the range of fully submerged cruising.

The equipping of nuclear submarines with nuclear missiles immeasurably increased their strike capabilities.

An especially difficult problem in combatting such craft is considered to be their search and detection, inasmuch as practically they can be submerged in any point of the water surface of the world ocean, deployed within the limits of firing range of their ballistic missiles.

It is not by chance that the American naval expert Corsa [Translator's note: correct spelling not verifiable from available references] notes with specific alarm that the number one problem in antisubmarine defense is the problem of the detection of a submarine which is submerged.

At the present time, as foreign specialists consider there exists an obvious disparity between the significant growth in the combat capabilities of atomic submarines and the lag in the development of means of combatting them, which is also caused by certain physical characteristics of the ocean medium, severely complicating the utilization of various types of energy for operating the airborne equipment for searching for submerged submarines.

Characteristics of the Sea Medium Which Complicate Searching for a Submerged Submarine

Any search is, in essence, a process of premeditated investigation of a section of a medium for the purpose of detecting a given object against its background. In the search for air targets the air space is inspected, in the search for submarines - the water environment of the sea or ocean regions in which their action is assumed.

Detection against the background of a surrounding medium can be conducted visually or with the help of technical resources.

Thus, for example, a radar station discovers an air target on the principle of the utilization of the features of high frequency waves of electromagnetic energy to reflect from the surface of the metallic parts of an aircraft and to be well propagated in the atmosphere.

However, in a water medium, short electromagnetic waves are barely propagated. Water shows very great resistance to them, as a result of which, a considerable part of their energy turns into heat. Furthermore, when electromagnetic waves strike a water medium from the atmosphere there occurs a reflection of them from the surface of the water.

The ability to be propagated in water is possessed by ultralong electromagnetic waves, however they reflect poorly from objects commensurable with submarines, and they require such bulky equipment for their radiation that their practical application in aviation is highly improbable.

Because of the reasons mentioned it is not yet feasible to use radio waves for the direct detection of submarines which are submerged. However, as the foreign press notes, this does not mean that in the future the principle of radar cannot be used at all in the creation of airborne means for the detection of submarines by any indirect criteria or phenomena which accompany their motion and are susceptible to recording by radar methods.

Light waves are propagated in the water medium also considerably poorer than in the atmosphere. In view of the severe scattering of light by the molecules of water itself and by particles suspended in the natural water medium, light waves can be propagated in it for short distances. Thus, for instance, even sunlight under favorable hydrometerological conditions can penetrate altogether only to a

depth of 80-100 m. In this case it is characteristic that the absorption of light in the red part of the spectrum occurs considerably more in water, than in the blue part. Thus, the application of light energy in a usual form for the operation of equipment for the direct detection of submerged submarines is highly unlikely. However the possibility is not excluded for its utilization in the form of a laser beam of blue-green light.

The more favorable conditions in a water medium for propagation are possessed by acoustic, especially infrasonic, waves. The velocity of the propagation of sound in water is approximately 4.5 times greater than in air, however in heterogeneous sea water it is not constant. It changes depending on temperature, salinity of the water, and, furthermore, on the pressure in water medium, therefore it increases with depth from approximately 1400 m/s at the surface of the water up to 1650 m/s at a depth of 10,000 m.

An essential feature of propagation of waves of acoustic energy underwater is their low attenuation, in consequence of which, underwater sounds can be propagated to considerably greater distances than, for example, in air. In the range of the audible frequency band (500-2000 Hz) the distance of propagation underwater of sounds of medium intensity attains 15-20 km, and in the range of ultrasonics - to 5 km. With the values of attenuation of sound observed under laboratory conditions in small volumes of water, it would be possible to expect considerably greater distances. However, under natural conditions, besides the so-called viscous attenuation caused by the properties of the water itself, there is also the effect of refraction of sound and its scattering and absorption by the fine foreign particles, which are always to be found in water.

The refraction of sound, or the bending of the path of a sonic ray, occurs as a result of three basic causes: the change in hydrostatic pressure with depth, the change in salinity, and the change in temperature because of the unequal heating of the water mass by the sun's rays. As a result of the joint effect of the

reasons mentioned the sonic rays which came from the source at a certain angle to the horizon, are bent, moreover the direction of the bend depends upon the propagation of the velocity of sound in the medium.

In summer, when the upper layers are warmer than the lower, the rays are deflected downward and a majority of them are reflected from the bottom, in so doing losing considerable energy. On the contrary, in winter, when the lower layers retain their temperature, but upper layers cool, the rays are bend upward and are reflected from the surface of the water, losing considerable less energy. Therefore in winter the range of propagation may be greater than in summer. As a result of refraction, so-called zones of silence are formed - areas located in the vicinity of the source, in which sound is not audible.

The propagation of high frequency sounds, when the lengths of the waves are very short, are affected by fine inhomogeneities: gas bubbles, microorganisms, etc. Such inhomogeneities absorb and scatter the energy of sound waves. Therefore, with an increase in the frequency of sonic vibrations, the range of their propagation is substantially shortened. This is particularly noticeable in the surface layer of the water where by far the most of the inhomogeneities are.

The scattering of sound by inhomogeneities, and also by the uneveness of the surface of the water and the bottom, causes the phenomenon of underwater reverberation, which is residual sounding preserved after switching off the source of the sound, caused by the arrival at a given point of late reflected or scattered sound waves. Reverberation is a rather considerable interference for a number of practical applications of underwater sound, especially for sonar, because it creates background noise, which limits the range of underwater detection.

Foreign experts attach great significance for underwater sound to the phenomenon of super-long range propagation of underwater sounds discovered by Soviet scientists. At a certain depth a layer

is found in which sound is propagated with the least velocity. Above this depth, the velocity of sound propagation increases because of the increase in temperature, and below - as a result of the increase in hydrostatic pressure with depth. This layer - a unique channel for the propagation of sounds because a ray deflected from the axis of the channel upward or downward, as a result of a refraction always tends to fall back into it. If the source and the receiver of the sound are located in this layer, then sounds can be recorded at distances in hundreds of kilometers.

The limits to the range of propagation of underwater sounds are also restricted by the natural noises of the sea. Some noises appear from the shock of the waves on the surface of the water, from sea surf, and rolling pebbles. Other noises are associated with sea fauna - with the sounds, produced by fish and other sea life.

The world ocean, which includes the Pacific, Indian, Atlantic, and North Arctic Oceans, has a surface extending more than 360 million km^2, i.e., more than 70% of the area of the globe, and it contains more than one billion km^3 of water and has a maximum depth of about 11 km. All this creates favorable conditions for concealed operation of submarines and serious difficulties for the application of means of detection. American experts consider that finding a submarine submerged in such an ocean jungle is more difficult than finding a needle in a haystack.

In this case, it is noted, that under these conditions, in order to battle confidently with the atomic missile submarines operating at various depths, it is necessary to have the means capable of round-the-clock control of the depths of many regions of the world ocean, which are calculated in millions of cubic kilometers, to adequately survey all regions from which submarines can inflict their missle strikes.

It is considered that the extremely difficult problem of search and destruction of submarines cannot be solved without further thorough

research on the features of the ocean and the phenomena going on in it and also the various characteristics of the state of the atmosphere over the ocean and the sea medium in finding a submarine in it. Therefore numerous scientific research organizations of the USA and its allies now are conducting investigations of the ocean under various programs. An especially important place in them is allotted to oceanographic investigations.

Program and Organization of Oceanographic Investigations

The USA has developed and is carrying out a special program of oceanographic and hydrological investigations of the world ocean for the next ten years (1961-1970) called "Tenoc." The main goal of the program - a search for ways to solve the problem of the creation of instruments for effective search and detection of atomic submarines.

The basic questions undergoing investigation in this program are: propagation of light, sound, and radio waves in sea water; salinity and temperature of the sea depending on depth and locality; the deep contours of the ocean; the distribution of magnetic fields and anomalies; the characteristics of wakes created by submarines; biological processes, noises in the ocean, and others.

Oceanographic works in the USA, in addition to the Naval Oceanographic Office of the Navy are also being pursued by civilian organizations. In connection with this, in the USA a national center has been created for the collection of oceanographic data, equipped with the latest computer machines. It has been assigned to gather, process, store and report on oceanographic data obtained as a result of the observations. Collection of data is being conducted in three direction: for current operational use (for example, for the prediction possible disturbances, and others), for hydrographic purposes, and for conducting scientific investigations.

To obtain valuable oceanographic information, in the USA wide use is made of stationary inhabited research laboratories and floating platforms created in the open sea, and also various sea-going vessels of the research fleet.

The U. S. Navy is conducting extensive operations in the creation and utilization of deep-water research equipment, various laboratory equipment and instruments for oceanographic studies. It is planned to build a bathyscaphe designed for a depth of submersion up to 11,000 m and unmanned underwater apparatuses.

Furthermore, the "Tenoc" program provides for installation of powerful automatic anchored and drifting buoys, an expansion in the scale of employment of aircraft and the [ISZ] (ИСЗ) artificial satellites of the earth to investigate the interconnection between the atmosphere and the sea, and finally the utilization of submarines capable of breaking the arctic ice.

Investigations in search and evaluation of nonacoustical principles of submarine detection are covered by the so-called "Unsound" program. It consists of the series of special investigations, including a study of the "windows in the ocean" for electromagnetic waves, research on the laws of motion of ionized particles in a water medium, determination of the possibility of the guidance of torpedoes to a submarine by its wake, investigation of the magnetic and gravitational disturbances caused by the presence of the masses of metal in a water medium, and others. Important significance is attached to the utilization of the "windows in the ocean," which permit infrared rays and electromagnetic waves to be propagated in water to great distances and depths.

On the initiative of the industrial circles in the USA, interested in obtaining profitable orders, a special committee has been created for antisubmarine warfare which includes representatives of 80 firms and 2000 specialists in antisubmarine warfare. The committee also shows greatest interest in research on means of detection and identification of underwater targets.

A specially created subcommittee of 50 persons are engaged in research on electromagnetic and acousting phenomena which take place in the medium surrounding the underwater target in research on the effectiveness of the means of search, in oceanographic investigations and the processing of the information obtained.

As yet the principle has not been found, on the basis of which it would be possible to create a universal means to ensure the rapid and effective detection of atomic submarines located at any point in the world ocean. Therefore, the efforts of the foreign specialists were directed to development and perfection of the means of search and the detection of submarines, each of which it operates on a specific physical principle.

Airborne Means of Search and Detection of Submarines

In creating the airborne equipment for search and detection of submerged submarines, the scientists are striving to use the entire complex of their unmasking criteria, their acoustic and magnetic fields, the thermal contrast of the wake of a submarine, the contamination of the atmosphere by the exhaust gases of diesel-engines in that spot where they were located, the increase in the radioactivity of the water medium as a result of operation of atomic power, and others. So far abroad they have managed to create airborne equipment for submarine detection, operating relatively successfully on hydroacoustic and magnetometric principles. Furthermore, an infrared apparatus, and an apparatus for detection of ionization have been developed, and the search radar sets have been improved.

Airborne Hydroacoustic Facilities

The hydroacoustic detection facilities include instruments based upon the utilization of the wave features of sound and ultrasonics: [RGB] (РГБ) sonobuoys, [OGLS] (ОГЛС) dipping sonar and [BGLS] (БГЛС) towed sonar.

Airborne sonobuoys. A wide variety of hydroacoustic means composing the armament of foreign naval airforces is represented in the systems of sonobuoys. In the USA two sonosystems have been accepted: the passive "Jezebel" (AQA-3) and the active "Julie" (APR-58). The "Jezebel" system detects a submarine from the noises being created by it, and the "Julie" - by means of picking up the echo reflected by the boat, which arose from explosion in the water of a small depth bomb thrown from an aircraft, called an explosive sound source. Both these systems consist of the sonobuoys jettisonable from an aircraft and an airborne radio-receiving device.

In principle, hydroacoustic detection of the underwater targets can be achieved either by a passive method, i.e., by intercepting the sound radiation of the submarine, or active, i.e., by means of radiation of sound waves in water and intercepting the sounds reflected from the submarine. Corresponding to these methods of location two types of sonobuoys have been developed abroad: a passive action RGB, and an active RGB. In the character of the diagram of direction of the hydrophones, sonobuoys are nondirectional and directed in action.

The simplest in construction are the passive buoys of nondirectional action which establish only the fact of the presence of submarine near them. For pinpointing the position of the boat detected by such buoys, it is necessary to employ directional buoys or other means of more precise definition.

An example of a passive buoy of nondirectional action is the American buoy AN/SSQ-23 (Fig. 28). It consists of a hydrophone, a system for the transfer of information about detection of an underwater target, power supply sources, and a marker device which serves for visual observation of the buoy. The whole apparatus and the power supply source are enclosed in cylindrical housing, which after landing on the water is divided into two parts. The lower part of the housing with the power supply source and hydrophone sinks with

the help of an elastic wire cable to the established depth, while the upper with the electronic equipment and antenna remains floating on the surface of the water.

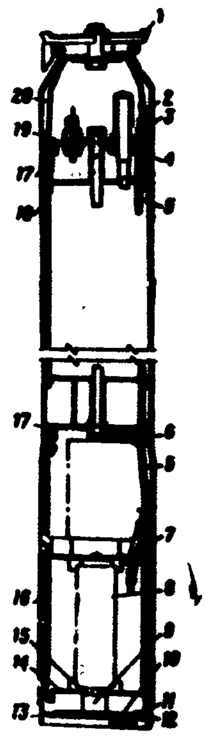


Fig. 28. A longitudinal cross section of the American AN/SSQ-23 sonobuoy: 1 - rotating head; 2 - retaining spring; 3 - upper release; 4 - upper watertight partition; 5 - guide tube of the release rod; 6 - lower watertight partition; 7 - block of dyestuff; 8 - hydrophone; 9 - leaf spring; 10 - latch spring; 11 - lower release; 12 - release latch; 13 - release plate; 14 - retainer plate; 15 - rubber shock absorber; 16 - guide tube; 17 - sealing gasket; 18 - extension blade; 19 - spring latch; 20 - jettisonable antenna case.

b softening the shock of striking the water, the buoy is supplied with special blades which are fastened on hinges to a revolving head, mounted on latches in the upper part of housing. After separation of the buoy from the aircraft, the blades are automatically extended and installed in a horizontal position, and are set in rotation by the incident counter flow of air as the buoy falls. The autorotation appearing thus reduces the rate of fall of the buoy to 18 m/s, and thereby protects its equipment from damage at the moment of striking the water.

Spring latches on striking the water, are triggered, as a result of which, the rotating head with the blades is separated and sinks. Simultaneously the polyethylene case of the rod antenna is

separated and sinks. A plate antenna, 75 cm in length in nonworking position is coiled into a ring tightened by a band of filter paper, and is placed lengthwise along the housing of the buoy. In the water the paper becomes soaked, the band breaks and the antenna, straightening, assumes a vertical operating position.

When the buoy hits the water the special plate which secures the acoustic receiver with cable in transport is separated from its housing, and after alighting sinks on this cable into the water to a depth of more than 10 m.

A storage battery is attached to rubber or spring shock absorbers in the lower part of the housing of the buoy. As an electrolyte, the battery uses sea water which falls into it through a special opening after the buoy has landed.

Auxiliary elements of the buoy are the dye which creates on the surface of the water a bright colored spot which serves as an orientator in visual observation of the buoy in the daytime, and mounted on the aluminum antenna panel a flashing electric signal light - for observation at night. For radar observation of the buoy, an active responder is mounted on it, which operates on the frequency band of the airborne radar equipment.

In order to sink the buoy after the termination of its work, there is a self-destruction device, which is a zinc plate 0.23 mm thick covering an opening in the housing of the buoy. On the periphery of one of the sides, the plate has a ring-shaped nickel coating 0.025 mm thick. In the central part not covered by nickel, the thickness of the zinc plate is 0.15 mm in all. As a result of the electrochemical process of a galvanic pair (zinc-nickel), the wall of the plate, after a specified time after falling into the sea water, is destroyed, letting water into the interior cavity of the water-tight part of the housing. The buoy fills with water and sinks.

The operation of the passive buoy is reduced to the following. After the buoy is thrown out into the water, its hydrophone, having dropped to a depth, picks up various noises including the noises of the submarines. These noises are converted into electromagnetic vibrations which enter an amplifier. The amplified signals modulate the carrying frequency of a miniature ultrashort wave transmitter and they are transferred by it in the form of radio signals into the ether. Reaching the airborne receiver, these radio signals again are amplified and are transferred to an indicating device.

The assembled AN/SSQ-23 sonobuoy is a cylinder 918 mm in length with a diameter of 127 mm, and overall weight of 9 kg. The dimensions and weight of a directional buoy is considerably more than those mentioned (a length of 1500 mm, and diameter of 200 mm). This is explained by the fact that its design (Fig. 29) is more complex than the design of the nondirectional buoy, inasmuch as a directional buoy serves not only for the detection of a submarine, but also for obtaining a bearing on it. In connection with this, there is in it an acoustic directional receiver, which possesses a narrow directional diagram.

The whole acoustic system together with the acoustic receiver during the operation of the buoy automatically rotates at slow speed. The reading of the bearing on a detected submarine is determined by an operator according to the signal maximum and he makes a calculation from the magnetic meridian. To do this, in the buoy a compass device is mounted rigidly connected with the acoustic system and included in the circuit of the radio transmitter of the buoy.

In a directional buoy there is a somewhat more complex transmitter 2 because the frequency of its oscillation is not only modulated by the picked-up noises of the submarine, but also changes depending on the position of the acoustic system. The indicator and receiving devices are also more complex. Furthermore, it has a bulkier brake parachute system consisting of three parachutes.

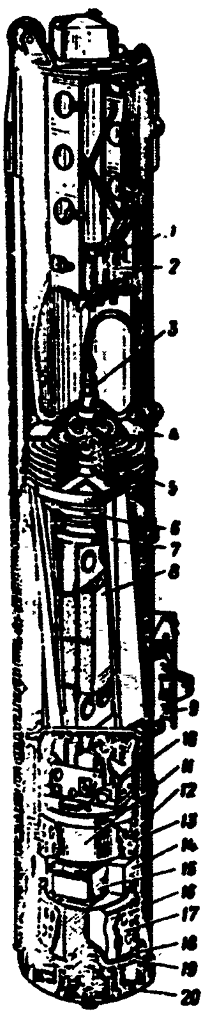


Fig. 29. Cutaway view of an English directional sonobuoy: 1 - transmitter chassis; 2 - transmitter; 3 - watertight six-channel connector; 4 - partition; 5 - cable; 6 - propeller drive; 7 - propeller blade; 8 - hydrophone; 9 - amplifier; 10 - amplifier and generator connected with a compass; 11 - compass; 12 - compass heater; 13 - cylinder; 14 - battery power supply of the electric motor; 15 - low-voltage battery; 16 - high-voltage battery; 17 - heater; 18 - bottom cover; 19 - fastening; 20 - nose cap.

After touching the water the directional buoy also divides into two parts. The upper part, consisting of a transmitter with antenna, remains floating on the surface of the water, and lower, which includes an acoustic receiver with amplifier *9*, an electric motor for the rotating receiver, a compass device with a generator and a power supply source, sinks in the water on a ten-meter cable line.

The following serve electric power sources: a 2 V lead storage battery *15*, a 145 V alkaline storage battery for the power supply of the electronic equipment, and a separate 14.7 V alakaline storage battery for the power supply of the electric motor. The minimum period

of service of these electric power sources is about 1 h, and depends on the temperature of the water. The proper temperature of the compass and the batteries prior to the dropping of the buoy is maintained with the aid of heater *17*, which is supplied from the 28 V on-board circuit of the aircraft.

The underwater part of the head of the buoy, containing a hydrophone, amplifier, generator and a magnetic compass, begins to rotate at a rate of 3 r/min, thus carrying out a circular scan. The indicator device (needle) of the compass is mechanically connected with one group of plates of the variable capacity capacitor. The other group of plates of the capacitor is rigidly connected with the housing of the head of the buoy.

During the operation of the buoy, the magnetic compass needle retains a position in which its poles are always directed on north-south line. Therefore, in the same position, connected with it is found a group of plates of the capacitor. With the rotation of the head relative to them, the other group of plates of the capacitor rotates, connected with the housing of the head of the buoy. In so doing, the capacitance of the capacitor and the frequency of the special generator change. From these changes it is possible to judge the orientation of the hydrophone relative to a magnetic meridian.

Information about the position of the hydrophone is supplied via connecting cable *5* to transmitter *2*, and then in the form of a radio signal on-board to the aircraft. Simultaneously, via a radio channel to the aircraft from the buoy, a signal can arrive regarding the noises of the submarine which is located in the zone of the reacting RGB. Thus, by means of the buoy, the operator can not only detect a submarine, but determine its location.

In English sonobuoys, which possess a transmitter with large output power, the data regarding a submarine are relayed in the 61 MHz range. The transmitting equipment of the buoys operates on 12 fixed frequencies of this band with an interval of 200 kHz between

adjacent frequencies. The presence of many channels makes it possible to receive information on the aircraft from several buoys.

The noises picked up by the hydrophone of the buoy are thus relayed to aircraft, helicopter, or blimp. The operator on the aircraft, picking up signals coming from a sonobuoy, listens to them, and then according to the special indicator which possesses a cathode-ray tube, determines a bearing for the submarine and calculates the elements of motion of the target necessary for the employment of an antisubmarine weapon.

In the USA there are the active buoys which operate on the principle of utilization of the echoes which appear as a result of reflection of sound waves from the underwater targets, which are formed by the explosions of special explosive charges jettisonable from an airborne carrier together with the buoys. Such airborne RGB are used in the "Julie" system. Furthermore, work is going on abroad in the creation of active buoys in which piezoceramic plates serve as the sources of sound.

On the airborne carriers, the RGB are placed in holders or special casettes (engine nacelles, Fig. 30).

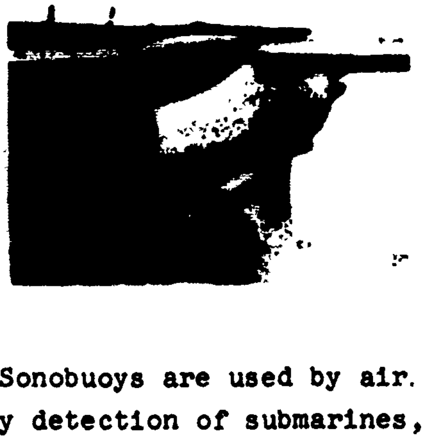


Fig. 30. Engine nacelle of S2F-3 "Tracker" an antisubmarine aircraft fitted with sonobuoys.

Sonobuoys are used by air forces for the detection of submarines. Primary detection of submarines, as a rule, is carried out, by passive nondirectional sonobuoys. To do this, in a region where a submarine is assumed to be, an aircraft drops a calculated number of such buoys

(Fig. 31) in definite sequence, so that they will be distributed on the surface of the sea in the probable path of the submarine, creating a continuous line or zone of detection. The distance between buoys is determined by their range of action, which depends upon specific hydrological conditions. When a submarine enters the zone of reaction of a buoy, its noise is picked up by the hydrophone of the buoy and relayed via a radio channel to the aircraft in the form of a signal which testifies to the appearance of a submarine in the region of action of the buoy.

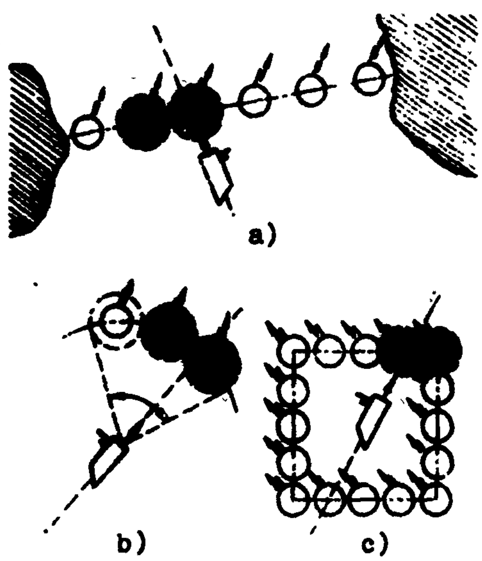


Fig. 31. Diagram of setting non-directional sonobuoys: a) linear intercepting barrier; b) sector intercepting barrier; c) encompassing barrier.

Upon receiving the signals from these radiobuoys, the operator determines the number of the buoy, the listening zone in which the submarine is located, and thereby roughly determines its location.

For more precise definition of the coordinates of the submarine necessary for employment of an antisubmarine weapon, directional buoys are used. For this purpose, in the region where the submarine is detected from the aircraft or another airborne carrier several directional buoys are dropped in such a pattern (Fig. 32) that they will encompass the assumed location of the submerged submarine.

the submarine, on the depth of its submersion, the sea conditions and a number of other factors. In the foreign press, for example, it was reported, that with a submarine speed of 6 knots (10.8 km/h) and a sea rating of 2-3, the range of detection of a modern submarine by passive buoys of sonic range comprises about 2 km. Under the best "lake" hydrometerologic conditions, the range of detection does not exceed 5 km. Sonobuoys of infrasonic range have a range of action of more than 10 km.

Foreign experts recommend using such airborne sonobuoys mainly for searching for submarines in limited regions on the basis of the data on their initial detection by other naval facilities or on the basis of criteria which indicate the possible location of a submarine in the given region. Sonobuoys are also used in the organization of antisubmarine barriers and for creation of barriers on the flanks of ship formations and convoys in regions in danger from submarines.

A substantial deficiency in RGB along with the short range of detection is, in the opinion of foreign experts, the one-time character of their use and their limited time of operation, in consequence of which in searching for a submarine over extensive areas, and also during prolonged tracking of them, it is necessary to systematically launch new sets of buoys while the reserve supply of them on an aircraft is limited. Thus, for instance, on the "Tracker" antisubmarine aircraft a complete set consist altogether of only 32 buoys, on the "Neptune" aircraft - 37, and on the "Orion" - approximately 100 RGB. Therefore, investigating extensive sea areas, requires a large detail of aircraft and colossal expenditure of expensive buoys. Specifically, the U. S. Navy annually buys about 200,000 sonobuoys. As pointed out in the foreign press, the cost of a complete set of sonobuoys and equipment for it comprises 35% of the cost of the entire armament of an antisubmarine aircraft.

All these serious disadvantages of sonobuoys are forcing naval experts in the USA and Great Britain to undertake measures for their further perfection. In the first place, they are trying to [illegible]

the time, and also the range of action of RGB, especially, by means of utilization of low (subsonic) frequencies and, secondly, to decrease their overall dimensions and weight without impairing their performance characteristics.

In the USA, a nondirectional buoy has been created which has spherical form and considerably less weight, than those now in the armament. The new buoy does not require a mechanized rotator to retard descent after being dropped from the carrier because in it miniature printed electronic circuits are used. These circuits in the housing of the buoy are fixed on special shockproof shock absorbers which permits dropping the buoys into the sea from altitudes up to 3000 m. The reserve supply of such buoys on an aircraft can be increased, and their cost lowered.

The list of new airborne sonobuoys includes the jettisonable device of the Lorelei type. This buoy is used for the more precise definition of the position of submarines and it can operate both in a passive, and also in an active mode.

The press reported that the U. S. Navy is developing a new, larger overall, and with longer life airborne RGB under the name "Lolita."

Airborne dipping and towed sonar. The ability of helicopters and blimps to fly at a comparatively slow speed and to hover over a specific point on the surface, has served as the basis for the creation and use with them of dipping and [GAS] (ГАС) towed sonar transducers. The sonar being created and planned at the present time abroad acts on the same two principles as RGB. In the first place, on the principle of recording of the noise (sound) field which appears in water during the motion of a submarine, and, in the second place, in the utilization of the echoes reflected from an underwater target during its irradiation by the acoustic energy of the station itself.

Corresponding to these principles there are two modes of GAS operation: the sound-bearing (listening sonar) observation mode - [ShP] (ШП) and the sonar observation mode - "echo bearing."

During sound-bearing mode the sonar detects and determines the direction - the bearing to an underwater target from the noise being created by the operating propellers, mechanisms, etc. In so doing, it does not itself emit any acoustic energy into the water medium, which makes its operation very secret. The effectiveness of the passive sonar observation depends entirely upon the level of noises being created by the submarine.

In recent years intensive work has been conducted towards reducing the noisiness of submarines. Therefore, as the noise of the submarine is reduced, the effectiveness of such sonar will drop.

A serious disadvantage of the sound-bearing mode is considered to be the impossibility of determining distance to the object making the noise. In connection with this, a second sonar mode of operation is used, in which for the detection of an underwater target a sonar transducer emits acoustic energy into its surrounding and records the part of it reflected from the underwater target and which returns to the point of reception in the form of an echo signal.

In the "echo" mode the sonar transducers determine not only bearing, but also distance. According to this data, in a number of cases, it is possible to calculate the depth of submersion of the submarine.

Sonar observation provides great advantages in comparison with the ShP mode, especially under modern conditions, when the struggle to reduce the noisiness of submarines has already achieved considerable successes.

A disadvantage of the sonar mode of operation is the possibility of detecting (overhearing) the operation of sonar by the enemy from the acoustic energy being emitted by him.

The armament of NATO antisubmarine aricraft now includes two types of sonar: dipping and towed. Structurally, each of them is made in the form of two blocks: an acoustic system contained in a special fairing lowered into the water, and an airborne indicator.

The acoustic system serves for radiating and reception of waves of sonic or ultrasonic frequency. The basic element of the acoustic system of any sonar is the electro-acoustic transducer which serves for conversion of electrical energy into sonic and vice versa.

The principle of such a conversion of energy is based on the phenomena known from physics of piezoelectric and magnetostrictive effects.

A piezoelectric effect consists in the fact that some crystals change their sizes under the effect of electrical voltage applied to them, and, on the contrary, emits electrical charges if we change the dimensions of the crystals by means of their compression or extension in specific directions.

Of the natural crystals, this effect is possessed by quartz and tourmaline, among the artificial - Rochelle salt, barium titanate, and ammonium dihydrophosphate.

On the basis of the magnetostrictive effect lies the phenomenon of the change in degree of magnetization of a ferromagnetic rod with its deformation. It is possessed by all ferromagnetic materials: iron, cobalt, nickel, and their alloys.

The operation of the sonar elements consists of the following. When the set is turned on, variable electrical voltage developed by an electric oscillator, is transferred through the relay of the receiver-transmitter *4* to vibrator *1*, (Fig. 33), which emits a short series of ultrasonic waves (the duration of one pulse is about 0.1 s). After the radiation of the relay of the receiver-transmitter automatically connects the vibrator to amplifier *5*. The necessary reflected

ultrasonic signal from the vibrator (in the receiving mode) reaches the amplifier, is converted into oscillations of low frequency, and is then supplied to an indicator where the signal is reflected on screen 8, or is heard in telephone 7.

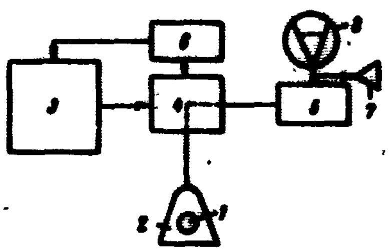


Fig. 33. Sonar block diagram: 1 - vibrator; 2 - fairing; 3 - electric oscillator; 4 - receiver-transmitter relay; 5 - amplifier; 6 - control panel; 7 - telephones; 8 - indicator.

In the majority of American sonar stations sonic frequencies in a band from 3.5 to 15 kHz are used, but there are stations known which operate on ultrasonic frequencies in the 20-25 kHz band.

At first, sonar were created which could listen to the whole space around the point of their submersion gradually ("step by step") and they were called step sonar.

Step sonar includes, for example, the English dipping [GLS] (ГЛС) sonar (Fig. 34) installed on the antisubmarine helicopters made by the Westland firm. Sonar has been designed for providing for the search for submarines and other underwater targets and the establishment of underwater ultrasonic communication.

The basic structural element of sonar - the electro-acoustic transducer - has been placed inside a special fairing. In the fairing, along with it, is placed a compass with an electric pickup which is part of the remote control system of the position of the transducer. The complete set of the equipment of the station includes a [illegible] and indicator instruments which show the flight altitude of the helicopter and the depth of submersion of the transducer. A special instrument measures the length of the etched cable. A station can operate in two modes: in hydrophone mode with continuous rotation of the acoustic system and in active step search mode.

Fig. 34. General view of English dipping sonar for a helicopter.

The dipping step search sonar DOAV-1B for a helicopter was developed in France. It was assumed that it would have a piezoelectric acoustic system with automatic and manual control with an overall weight of the set of about 225 kg. In the foreign press it is noted that step search sonar have a substantial disadvantage - their horizon scan time is too great. Investigation of the whole horizon takes 3-5 min.

In order to decrease the time of search, in recent years in the USA, Great Britain, and France they began to develop a circular scan sonar which permits scanning the entire horizon in 8-10 s.

Rapid investigation of the horizon is achieved by means of simultaneous radiation of energy in a 360° sector and the automatic reception of reflected signals from surface and underwater targets by means of the directivity characteristic rotating at a specific rate.

For purposes of increasing the reliability of target detection, the time of one revolution of the directivity characteristic does not exceed the duration of the transmission signal. Directivity

characteristic being artificially formed during rotation permits automatic determining of the bearing to the target in a horizontal plane.

A semicircular scan sonar the dipping GLS Bendix AN/AQS-10 developed in 1959 in the USA, intended as armament for the SH-3A "Sea King" antisubmarine helicopters. In one send operation this station scans a sector of 180°, and in two send operations - the entire horizon. It has the visual and audio indication of echoes received.

It has been reported that the American firm of Bendix concluded a five million dollar contract with the Bureau of Weapons of the U. S. Navy for production of the AN/AQS-13 dipping sonar with circular scan, intended for installation on the SH-3A "Sea King" helicopters.

The equipment of this dipping sonar consists of a vibrator housed in rubber, reminiscent of a bell in form, and amplifying-indicator instruments located in the cabin of the helicopter.

The housing of the vibrator has two sections - upper and lower. In the upper section there is the motor used for rotation of the vibrator, and in the lower - the vibrator proper and the hydrostatic instrument by means of which the depth of submersion the vibrator is controlled.

In range of action, depth of submersion of the acoustic system, and reliability, the AN/AQS-13 sonar exceeds the AN/AQS-10 sonar. In it the time of descent of the sonar into the water and the time of circular scan have been shortened, and higher accuracy in determination of distance and bearing to the target has been achieved. The dipping sonars are used by helicopters, but the possibility of their use with blimps and seaplanes is not excluded.

The armament of antisubmarine helicopters of the USA includes several modifications of the AN/AQS-2 towed sonar which possesses the greatest range of detection of submarines up to 4 miles. The

total weight of this equipment seemingly does not exceed 150 kg. These sonars are installed in blimps.

The AN/AQS-4 dipping sonar is intended as armament for anti-submarine helicopters. It is a characteristic for the new locators that the low frequencies are used in them, which permit achieving long ranges of detection.

To search for submarines with a [OGAS] (ОГАС) dipping sonar transducer, the helicopter descends over the listening point to 5-10 m (Fig. 35) and on a special cable line lowers the acoustic system into the water to the depth selected in accordance with the calculation of the hydrological conditions of the region, and for 2-3 min listens to the water area in the radius of action of the set.

Fig. 35. Canadian helicopter with a torpedo on board conducts observation by means of dipping sonar.

After listening, the acoustic system is raised and the helicopter flies to another point where it repeats the same operation. All this takes about 7 min. The interval between the hovering points is selected in such a way that the neighboring investigated zones somewhat overlap each other and between them no uninspected space remains. The flight altitude during the search is approximately 10 m, and the average speed of search - on the order of 17-20 knots (32-34 km/h).

In connection with the difficulty of precise removal of the helicopter to the next listening point, it is controlled during the time of search by ships which report the next points for lowering the vibrators, and also the flight courses to them.

Sonars towed by blimps can conduct considerably better search. Their action is most effective at a towing speed of up to 35-40 knots (65-74 km/h). However the carrier in this instance must accurately maintain the flight route in order that the search zone will remain continuous.

The U. S. Naval Electronics Laboratory, is working on improving the characteristics of sonar equipment, is paying special attention to the perfection of the means of the isolation of an echo and noises from a submarine against the background of interferences from sea fauna and various phenomena in the ocean, and also on improving the characteristics of electro-acoustic transducers. Foreign experts note that the increase in the range of detection by active sonar means can be achieved by lowering the operating frequencies and by the application of very powerful sources of radiation with a sharp directional pattern.

In this connection, the American firm, Acoustic Associates has developed for sonar sets a rod emitter with narrow directional pattern along the axis. The appropriate selection of the operating frequency and the dimensions of the disc-shaped ribs on the housing of the rod permits producing a phase velocity of longitudinal sonic vibrations of the rod equal to the speed of sound in the surrounding medium. The width of the directional pattern of the emitter is determined mainly by the ratio between vibration velocities in the rod and the surrounding medium and the length of the rod. Such emitters can be created for powers on the order of a megawatt.

Magnetometric Equipment for Search and Detection of Submarines

In the period of World War II in the laboratories of the American Bell Telephone Company, an aeromagnetometer was created, MAD (Magnetic Anomaly Detector - a magnetic detector) - an instrument intended for detection, classification, and tracking of a submerged submarine when it is extremely difficult to detect them from the air by other means.

The physical basis for the creation of the aeromagnetometer was the magnetic properties of the earth and the metallic hull of a boat. It is known that earth possesses a magnetic field, under which is understood the circumterrestrial space where the force of the earth's magnetism is manifested.

The average intensity of the earth's magnetic field is about 0.5 Oe (oersted) or 50,000 γ (gamma). The strength of the magnetic field of the earth increases from the magnetic equator to the magnetic poles. Its magnitude at the equator comprises 25,000 γ, and at poles it reaches 65,000 γ.

The magnitude of deviation in the strength of the magnetic field at a given point of the earth from its average value is called the gradient. The horizontal gradient of the strength of the earth's magnetic field comprises approximately 10-15 γ/mile. With an increase in altitude, the strength of the earth's magnetic field diminishes. Its vertical gradient amounts to about 30.5 m/γ.

The hull of a modern submarine also possesses a magnetic field which has a strength of not less than 0.0001 the strength of the earth's magnetic field (a few gammas). Because of this, the presence of the submarine at one point or another in the water expanse introduces a change (anomaly) in the distribution of the earth's magnetic field.

The operation of the aeromagnetometer is based on the principle of recording the indicated changes in the earth's magnetic field caused by the metallic hull of the submarine. The aeromagnetometer is an electrodynamic magnetic device the axis of which has been matched with the direction of the earth's magnetic field. A block diagram of such a magnetometer is shown in Fig. 36.

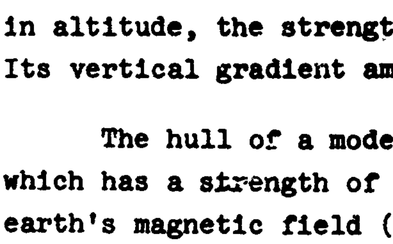


Fig. 36. Block diagram of an aeromagnetometer (MAD): 1 - sensing element; 2 - alternating signal amplifier; 3 - detector (filter); 4 - direct signal amplifier; 5 - correcting device; 6 - compensating device; 7 - recording device.

A ferromagnetic core, which possesses three windings serves as the sensor: a basic one (measuring) for measurment of the changes (anomalies) in the earth's magnetic field and two auxiliary windings. One of the auxiliary windings governs in an assigned range the magnetic permeability of the ferromagnetic core; the other - compensates the constant force component of the magnetic flux being directed in the basic (measuring) coil by the pressure on it of the earth's magnetic field. As a result on the output of the measuring coil a signal appears, being directed in it only by the magnetic field of a submarine or other object falling in the zone of reaction of the magnetometer.

Amplifier 2 serves to amplify the signal being taken from the measuring coil. Detector 3 converts this alternating signal into direct, and amplifier 4 amplifies it. The amplified direct signal is fed into the recording device, which is a recorder possessing four rates of pulling a paper tape: 30.5; 7.5; 2 and 0.5 cm/min.

The aeromagnetometer is very sensitive to different kind of interferences appearing as a result of the effect of the magnetic field of an airborne carrier and the change in its flight condition. These interferences affect the result of recording the signal, therefore great skill is necessary on the part of the operator to be able to distinguish between the signal of the submarine and an interference signal. To disclose a signal from a submarine, some of their characteristic features can be used: class status (the number of maximums or "peaks" in a signal), duration (the interval between two peaks), amplitude (the amount of span between two peaks), and finally by the polarity of the signal, i.e., by the direction of the motion of the pen of the recorder upon appearance of a signal. Polarity is positive when the pen moves to the right and negative - when it moves to the left.

When the aeromagnetometer operates at range limit the signal becomes weak, and it becomes impossible to define it according to the named characteristics.

The duration of existence of a signal from a submarine depends upon the altitude and speed of flight over the submarine. Thus, for instance, at an aircraft speed of 220-300 km/h and a flight altitude on the order of 100 m, duration comprise 1 s. Total duration of signal observation is counted from the beginning of the first blip to the end of the next one. It amounts to 3-5 s.

The range of detection by a magnetometer depends on its technical characteristics, magnetic mass (displacement), and the course of the submarine. The maximum range of action of foreign magnetometers does not exceed 300 m. The width of the zone being scanned by the aeromagnetometer is affected by the flight of the carrier and the depth of submersion of the submarine, with a reduction in the flight altitude the width of the search zone being scanned and the depth being investigated by means of the magnetometer increases (Fig. 37). This requires conducting a search by magnetometer at the lowest possible altitudes. At the moment a signal appears on the recording device to indicate a submarine the crew throws out a marker buoy which designates the spot marking its detection.

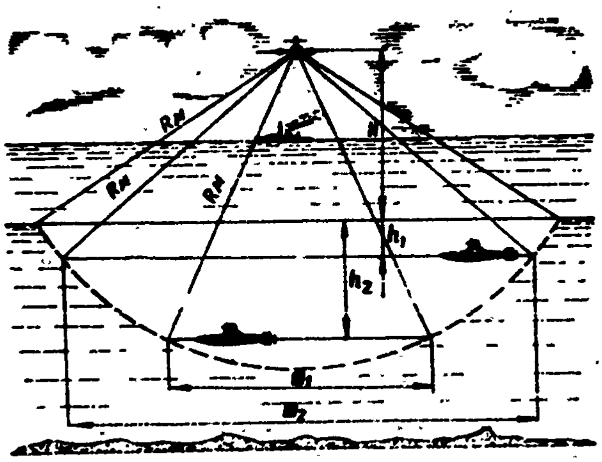


Fig. 37. Change in the range of action of a magnetometer with the flight altitude of the aircraft.

The tactical capabilities of magnetic detectors are as yet comparatively small. The utilization of magnetometers for an independent search of high-speed nuclear submarines in a large area is considered almost useless because of the small radius of detection. Therefore, foreign experts recommend using magnetometers basically for tracking a previously discovered submarine and to define its position more precisely. The use of a magnetometer in combination with other means of search, for example with sonobuoys, increases the effectiveness of this or other systems.

Work is being conducted abroad on the "A-New" program directed towards increasing the range of action of aeromagnetometers and in discovering the possibilities of detection of submarines at great depths. For this purpose, in the first place, ways are being sought to increase the sensitivity of the equipment and to reduce the level of the magnetic interference of the aircraft. The latter can be achieved by compensation of the magnetic interferences and also by shifting the location of the sensing element of the detector on the aircraft to a place where intereferences are minimum, or by a combination of both measures, which in the opinion of American experts can most successfully be decided when designing the aircraft.

On modern American antisubmarine aircraft the sensing element of the magnetometer is located behind the tail assembly in a special nonmagnetic fairing (Fig. 27) with a length of several meters or, as, for example, on "Tracker" aircraft, in a fairing which is extended in flight on a rigid boom.

The U. S. Navy recently conducted a test of two new aeromagnetometers, the principle of the action of which is based on the utilization of electronic resonance in one case in alkali metal pairs, and in the other - in metastable helium. The sensitivity of these models has been increased ten times in comparison with the sensitivity of instruments with saturated magnetic cores, and comprises 0.01 gamma instead of 0.1 gamma in previous magnetometers.

The utilization of superconducting elements as airborne detectors of magnetic anomalies is considered very promising. Work is going on in the area of electromagnetic detection in the range of radio frequencies for the purpose of creating an ultrahigh frequency device.

Some U. S. scientists propose that for expansion of the capabilities of magnetic detectors a large number of phenomena still not studied can be used, and that concentration of efforts in these directions can rapidly produce practical results.

Despite the limited capabilities of magnetic detectors, all antisubmarine aircraft of the NATO countries have been equipped with them. The latest American aircraft have been equipped with the AN/ASQ-10 magnetometers, which have been in the armament since 1952. Foreign experts assert, that the installation of magnetometers on the helicopters is entirely practical.

Infrared Equipment for Search and Detection of Submarines

Considerable attention is being paid abroad to the development of a means of search operating on the principle of utilization of the energy of infrared (thermal) radiation.[1] It is known, that during motion of a submerged submarine there occurs a certain heating of the water particles from the shock and friction of the hull on it, and also the mixing of layers of warmer water with colder. As a result, behind the submarine there is created a thermal trail (wake) of displaced water.

In specific weight it differs somewhat from the rest of the "undisturbed" mass and therefore, gradually rising upward, it comes to the surface of the sea. Since this wake was formed by the mixing

[1]Under infrared radiation is understood the transfer in space from the target to a receiver of energy by means of the variable field of electromagnetic waves with a length of from 0.75 to 300 μ (0.0037 to 0.3 mm).

of the lower layers of water which always differ in temperature from the upper, then there will be found on the surface a thermal (temperature) contrast between the wake and the background of the sea. The absolute value of this temperature drop depends upon the thermal conditions of the sea, the degree of its agitation, the depth of submersion, the rate of motion of the submarine, and other factors.

With average temperature conditions and depths of submersion of a submarine up to 30 m, the difference in the temperatures of water in the wake and the surrounding water medium fluctuates within limits of from 0.05 to 0.5°C. Because of the temperature differences, the surface of the sea in the wake of the submarine will emit different thermal energy. Therefore, the wake of a submarine can be "seen" (sensed) against the background of its surrounding water medium. This phenomenon has served as the basis for the creation of instruments for the detection submarines by recording the thermal track formed on the surface of the sea after their passage (Fig. 38).

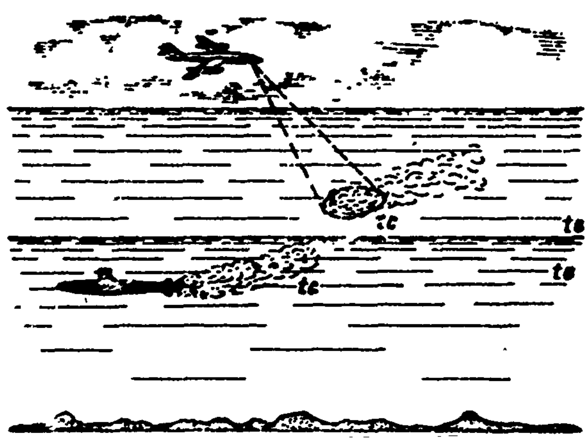


Fig. 38. Detection of a submarine by recording its thermal track: t_B - temperature of the water surrounding the track; t_c - temperature of water in the track.

The first infrared technique instruments were used even in the period of World War II for the detection of surface ships. Even then

their prospects were noted for the solution of a number of tactical problems at sea under favorable weather conditions. Therefore it was not by chance that in the postwar period the work in the area of naval application of such instruments was enlarged and began to cover questions connected with the detection not only of surface ships but also submarines. In connection with this, abroad several methods of recording the thermal field of the wake or the hot exhaust gases of operating diesel submarines are being investigated. One of them is based on the utilization of special airborne passive thermal detectors with highly sensitive indicators, which operate in the longwave section of the infrared spectrum.

Such infrared search equipment consists of a monoblock design which includes an infrared detector, electronic amplifier, and a system of visual indication.

In the post-war years in the USA a thermal detector has been created for blimps, which is sensitive to drops in temperatures to 0.0001°C, by means of which it is allegedly possible to detect a submarine at depths of up to 40 m. Such an instrument is the American airborne thermal detector.

Another method of recording temperature drops consists in utilization of aerial photography in the infrared section of the spectrum. The American firm of Singer has developed a "Reconofax" camera which is sensitive to detection of the temperature contrast of the wake of surface ships from altitudes of more than 1000 m.

Passive radar methods are also used for recording temperature drops in the wake. They are based on the reception of thermal radio emission of ground, air, and sea targets in the millimeter and centimeter wave bands. In the process of flight tests conducted in the USA, a passive radar distinctly recorded the boundary between water and land under conditions of thick mist at a flight altitude of about 2000 m, and also the course of ships in a harbor from the thermal contrast of the wakes. In tests of the equipment operated on the

8 mm, 1.25 cm, 1.8 cm and 3 cm waves and in all cases positive results were achieved.

In the opinion of foreign experts, the infrared means of searching for submarines possess a number of advantages. They permit conducting a search at any time of day. Being passive, the infrared means cannot be detected by the enemy.

The thermal search equipment is simpler with less weight and overall dimensions than radar designed for the same purpose and having the same range of action. The simplicity of the design, naturally, determines the higher reliability of the infrared search equipment in comparison with radar.

The passive principle of action and the possibility of a simple means of getting rid of the interference effect of background make the infrared search equipment less subject to interference on the part of an enemy in comparison with radar and sonar.

However, as the foreign press points out, infrared equipment has two serious disadvantages. It operates normally only in good weather. In mist and strong rain, the range of action of the equipment is sharply reduced. Furthermore, as yet such means can only reveal submarines which are running at shallow depths and at increased speeds under a condition of the wake reaching the surface of the sea. All this forces the use of infrared equipment in conjunction with other means for the detection of submarines, for example with sonobuoys.

Nevertheless, despite the serious deficiencies mentioned, the latest American antisubmarine aircraft, the P-3C "Orion" has been equipped with an experimental installation of an infrared system for submarine search "Clinker" and its inclusion is proposed subsequently in a complex search-aiming system.

Radar Stations for Submarine Search

Searching for modern submarines which possess a fundamentally new mode of underwater motion by radar means is considered ineffective. In spite of this, abroad they continue to develop radar stations [RLS] (РЛС) to search for diesel submarines and to install them on antisubmarine aircraft, blimps and even helicopters.

At present the airborne antisubmarine armament of the USA includes the AN/APS-20, AN/APS-59, AN/APS-80 and AN/APS-88 radar sets which are able to locate submarines on the surface, at periscope or [RDP] (РДП) snorkel depth.

On antisubmarine aircraft usually two RLS are installed; one for long-range search of submarines, and another - for short-range search and reliable maintenance of contact with a submarine during the attack. The search RLS which is mounted for example, on the S-2 "Tracker" antisubmarine aircraft, has a pulse output of 75 kW and operates over the 2.75-5.77 cm range. The RLS antenna mounted under the fuselage of the aircraft is stabilized and provides a circular scan. The dimensions of the antenna mirror are 1 × 0.5 m.

The range of detection of submarine by modern airborne radar comprises: on the surface - about 50 miles, at snorkel depth - 10 miles, and at periscope depth - 1-2 miles. The range and reliability of radar detection of submarines at periscope and snorkel depth, to a considerable degree, depend on the state of the sea.

The Department of the Navy of the USA, under the "A-New" program is conducting work on the creation of new types of RLS for antisubmarine aircraft with long range of action and high resolving ability.

In February 1960 in the periodical "Electronic News" it was reported that on American antisubmarine aircraft for the detection of submarines magnetic side-scanning radar stations can be used

(Fig. 39). Such a station, the AN/APQ-55 was developed by the firm "Texas Instrument." The station operates in the 3 cm wave band.

Fig. 39. The position of the side-scan radar of the AN/APQ-55 on an aircraft.

In the USA an airborne RLS has been patented which is intended for detection of submarines in submerged position. The principle of the action of the system is based on the modulation of the radar signals reflected from the water, being created by the moving boat, moreover this modulation is easily distinguished from modulation being created by the other objects. Stationary underwater objects are not discovered with this system.

The possibilities are being investigated for employing for purposes of antisubmarine warfare, passive radar means based upon detection of thermal radio emissions in millimeter and centimeter wave bands. It is proposed that these passive radar means will permit recording thermal radiation of the wake of a submarine.

Equipment for Detection of Ionization

The list of nonacoustical means of searching for submarines includes equipment which reveals the pollution of the atmosphere by exhaust gases released by the diesel engines of a submarine through the snorkel equipment and capable of causing ionization of the air, and also the possible radiation contamination of the air in the passage of atomic submarines.

In the USA, special aviation equipment is also being developed for detection of atomic submarines, which will be able to measure the

radioactivity of the water caused by passage of a submarine with a nuclear power plant through a given region. It goes without saying that these means can be used both separately and also in conjuction with other means for detection of submarines.

In recent years in the USA equipment has been developed for the detection of submarines, conventionally called "Sniffer," the operation of which is based on gas analysis of the air. The "Sniffer" gas analyzers have already entered the armament of antisubmarine aircraft and bear the designation AN/ASR-2.

It was reported, in particular, that the American Navy has contracted with the Singer Manufacturing Company to manufacture 800 AN/ASR-2 instruments for installation on antisubmarine aircraft. Such instruments allegedly are already established on the "Tracker," "Neptune," and "Orion" aircraft and have shown good results. The action of the instrument is based on the discovery of small particles of carbon monoxide which are contained in exhaust gases escaping through the snorkel device. The sensing element of this instrument is placed under the wing of the carrier.

During the flight of the aircraft, the "Sniffer" instrument takes about five samples of air per second. Particles of carbon monoxide collected in this way are moistened. The hydrocarbon formed as a result of this moistening is easily detected with a photocell mounted in a special chamber of the gas analyzer. The effectiveness of the action of the "Sniffer" equipment depends upon the quantity of samples taken, the force of the wind and the altitude of flight. It was reported in the foreign press that the airborne gas analyzer of the AN/ASR-2 type detects a submarine while the aircraft flies at an altitude of about 500 m.

The English have also designed a similar instrument called the "Autolycus."

Searchlights

To facilitate the search and attack on submarines which are located on the surface during the dark period of the twenty-four hours, on antisubmarine aircraft searchlights with a power from 70 up to 130 million cp are used.

The latest of them is designated AN/AVQ-3. It operates on the principle of a voltage arc and is hung under the wing of the aircraft. In operation it is switched on either manually, or automatically by the radar set, which has detected a submarine, and can continuously illuminate a target for a prolonged period of time (the old model searchlights could continuously shine for not more than 30 s).

Other Means of Search and Detection of Submarines

Taking into account that as yet not one of the known means provides high effectiveness of search, and consequently, the destruction of submarines, runnin at depth, in NATO countries other physical principles of their detection are investigated.

Recently abroad, especially in the USA, the possibility of application of the television principle by antisubmarine aircraft for detection of submarines at low level of light intensity is thoroughly being studied.

Investigations are conducted on the creation and utilization of facilities, based on the application of optical quantum generators (OKG) or lasers, for search of submarines. Optical quantum generator – physical instrument, giving narrow directed beams of light, which are characterized by extremely high thermal energy.

The main part, or working (active) material, of the majority of solid OKG is a heavy crystal (rod) of synthetic ruby.

Thus, at present in the USA there are counted several dozens of types of solid-state lasers with output pulse power from 10 W to 500 MW. Any laser consists of three basic elements: the active material, which is the source of induced radiation, excitation (pumping) source, which supplies the active material with energy, and resonance device.

Figure 40 shows the diagram of an elementary laser, the active material of which is a ruby crystal, the pumping source is a xenon pulse lamp, and as resonator there are used the silvered faces of the ruby. One of the faces of the ruby rod (left) has a dense reflective silver coating, and the other (right) – a silver coating, which reflects light only 92%. In the center of this face there is a free (unsilvered) part, through which energy is emitted. As the power supply source of the xenon lamp there is a group of capacitors.

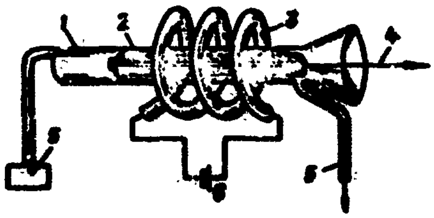


Fig. 40. Diagram of equipment of a ruby laser: 1 — glass tube; 2 — ruby rod; 3 — pump lamp; 4 — direction of energy emission; 5 — cooling system; 6 — power supply source.

During the supply of voltage to the xenon lamp it gives an intense light flash, under action of which most ruby atoms are excited (change to higher energy level). Some of the excited atoms spontaneously change into the main unexcited state, emitting light quanta in this case. The latter act on other excited atoms, forcing them to change to a lower energy level. This transition is accompanied by radiation of light quanta accumulated earlier. Thus, a quantum "avalanche" appears, which increases the energy in the direction parallel to the axis of crystal. As a result of repeated reflection from the mirror face of the ruby the avalanche of photons is extracted from the semitransparent face (right) in the form of a narrow light beam with very high energy concentration. The majority of solid lasers operate on the same principle as ruby.

When developing laser submarine search equipment the first stage in conducting these works was research of the conditions of propagation of light waves in sea water. The next stage was the creation of a special device for detection of underwater targets. Foreign specialists express that such a device sharply increases the ability to distinguish targets in comparison with ordinary underwater television equipment, which operates under conditions of simultaneous illumination of large volumes of water. As they propose, the range of detection will increase.

However, when using lasers for detection of underwater targets as yet long ranges of action are not attained. Thus, the range of a laser, which operates in the blue-green part of the spectrum, does not exceed 450 m, and then only at certain characteristics of sea water.

Along with the enumerated technical methods there is studied the capability of detection of a submarine by changes of characteristics of wave formation during its motion, by the turbulence zone, being left by it during motion, by the biological trace, being formed by perishing microorganisms, by the change of ultraviolet radiation of sea water and even by technical waste from the ship.

Search-Aiming System "A-New"

In connection with the fact that not one of the methods of detection of submerged submarines known abroad individually provides the complete solution to their search mission, there appeared the need for combination of search means, operating on various physical principles, into one search-aiming system (PPS).

The development of such a PPS as applied to one carrier since 1960 was carried out according to a special program, named the "A-New" project, by a group of American firms under the direction of the Office of Naval Armament of the U. S. Navy.[1] For carrying out this program the Pentagon has spent several tens of millions of dollars.

According to the project "A-New" there is planned the creation of two series versions of the search-aiming system: one – for installation on land-based aircraft – version "V_s," and the other version – V_p for equipping carrier-based antisubmarine aircraft. The basic distinction of the second version consists of less weight and smaller overall size.

In the composition of elements both versions are approximately identical and include AN/APS-80 radar set, coupled with radio equipment intelligence ALD-2 and radio countermeasure equipment; "Julie" and "Jezebel" sonobuoy systems, AN/AQS-10 magnetometer, AN/ASR-3 gas analyzer, system of optical means of observation of RGB and surface ships, digital radio communication system, a new tactical plotting board and as the link, which unites the operation

[1]Electronics" (USA, Russian translation), V. 39, 1966. "Naval Aviation News," 1965, March.

of all elements of the PPS, — computer, which is a miniature electronic computer.

Utilization of electronic digital computer on the aircraft and the new tactical plotting board on the aircraft facilitates the work of the aircrew. As is known, the crew of an antisubmarine aircraft must determine the release points of sonobuoys and the number of buoys in a series, select the frequencies for communication with each buoy to avoid interference and make other necessary calculations.

The installation of the electronic computer, according to the intention of the developers, should make it possible to automatically perform flight in open sea (over a route up to 1600 km in extent), accurately approach the region of search, continuously receive the present coordinates of the aircraft position, determine the optimum contour of arrangement of sonobuoys, track their position relative to the aircraft, find the position of a ship on the basis of all the obtained data, and also compare the effectiveness of several versions of actions of the aircraft.

The equipment of the "A-New" complex, besides precise reproduction of the mutual location of the aircraft itself, the position of sonobuoys and target, should also issue information about the surface situation and forces taking part in the search. For provision of operation of the system the cooperation of three crew members is required: pilot, navigator and the operator of antisubmarine warfare gear (tactical coordinator).

The prototype of the "A-New" equipment has already been created and undergone a series of laboratory tests. The results of the experiments with the prototype by a complex automatized system of collection and evaluation of information, received from detection instruments on the antisubmarine aircraft, were recognized as satisfactory, although there are deficiencies in the design.

Flight tests of the first modification of the "A-New" PPS prototype were conducted on the aircraft "Orion" in 1964-1966. The main goal of the tests consisted of a check of the effectiveness of search and detection of submarines with the aid of this search-aiming system and the development of final requirements on the tactical-technical characteristics of the series version of the system. The first version of the "A-New" search-aiming system entered the armament of the land-based aircraft P-3C "Orion" in 1969.

In the course of preparation and carrying out of the "A-New" program the USA changed the approach to development of the antisubmarine aircraft themselves. Until recently in the USA an antisubmarine aircraft was developed first, and then the means of ship detection were created for it. Now in the USA first the united complex of electronic detection aids is developed, and then the tactical-technical requirements for a new aircraft are determined. In the U. S. Navy since 1963 there has been conducted the development of new antisubmarine aircraft in accordance with this sequence.

The military circles of imperialistic governments — members of the aggressive NATO bloc and primarily the USA have great hopes for antisubmarine aviation, being equipped according to the "A-New" program. However, in the opinion of foreign specialists, the "A-New" system will not be able in principle to solve the acute problem primary search of modern submarines under ocean conditions, since all the elements entering it have limited search capabilities.

Space Means in the Antisubmarine Warfare System

In foreign naval forces there is urgently studied the question of utilization of artificial earth satellites for the purpose of submarine warfare. Foreign specialists consider that from satellites and manned space stations with the aid of special equipment it is possible to directly observe the ocean surface for detection of submarines underwater. In the USA there has been adopted a special

"program 287," according to which a manned space laboratory is being developed, designed specifically for solution to such a problem of antisubmarine warfare.

Furthermore, they consider it possible with the aid of multipurpose artificial earth satellites to determine the moment and launching position of ballistic missiles from atomic submarine-rocket carriers, providing timely warning of antisubmarine forces about the beginning of launch of missiles and to calculate their flight trajectories. With the presence of six-eight satellites in orbits it can be attained that two of them will constantly observe the vast water surface on earth. In the USA two projects of such satellites were considered – for circular orbit injection with altitude up to 1100 km and synchronous orbit injection with altitude about 36,000 km. Works on their creation are conducted by a group of American firms, being headed by the firm "Lockheed."

However, foreign specialists perceive the widest utilization of satellites for antisubmarine warfare purposes in their application for extraction and relaying of information from a global system of powerful sonobuoys, which can be placed in a definite order in the ocean in zones of the possible appearance of enemy submarines.

Navigation and Communication Means of Antisubmarine Aviation

Every antisubmarine aircraft, besides means of search and destruction of submarines, carries communication and navigation equipment, without which operations in contemporary war are impossible. Therefore, in the U. S. Navy and the naval forces of U. S. allies considerable attention is given to the development and equipping of antisubmarine aviation with navigation and communication means.

Navigation Aids of Antisubmarine Aviation

For the solution of problems of detection of submarines and determination of their location the contemporary types of antisubmarine aircraft have three separate navigation systems:

1) long-range navigation system;

2) tactical system for determining the aircraft position relative to a predetermined point;

3) radio navigation system.

These systems are installed, for example, on the aircraft P-3A "Orion." The first of them is applied for guiding the aircraft to the search region and consists of a series of elements, which can be used individually or combined. It includes an inertial navigation system (INS) AN/ASN-42 with correction from an induction magnetic compass.

The principle of action of inertial navigation systems (INS) consists of measurement of acceleration in three mutually perpendicular directions and one or two time integrations. This gives an instantaneous value of the speed and position of the aircraft in the selected coordinate system. Such a system continuously gives magnetic and true courses, ground speed, path passed, track angle and aircraft position coordinates. Simultaneously information is obtained about the aircraft spatial attitude.

The advantage of inertial systems involves their complete independence, impossibility of jamming and simplicity of operation. However, the accuracy of INS in determining the ground position of an aircraft is low and the error for an hour of flight reaches 1.8-3.6 km and subsequently increases still more. At high latitudes (over 70°) during navigation the orthodromic coordinate system is used.

In flights over very great distances besides the INS there is applied a periscopic sextent, B6 indicator drift, and also the long-range hyperbolic radio navigation system "Loran" AN/APN-10. This is a low-frequency pulsed hyperbolic system, designed for precise determination of the ground position of aircraft (and ships), and also for bombing targets under severe weather conditions. The accuracy of determination of aircraft ground position with utilization of the "Loran-C" system does not depend on the duration of flight. The mean square error in determining the ground position with the aid of this system is 30-600 m.

The range of the system in flight over land reaches 1900 km, and over sea – 3600 km.

The "Loran-C" system consists of several groups of ground stations and airborne aircraft equipment. The first chain of stations was constructed in 1959; at present there are six chains with 26 stations, already widely utilized by the U. S. fleet for navigation of submarines, armed with "Polaris" missiles.

Each group of ground stations includes one master and two or three slave stations. The distance between the master and slave stations is on the order of 900-1450 km. Each of the transmitting stations occupies an area of about 22 ha. The transmitting antenna has a height of 190 m.

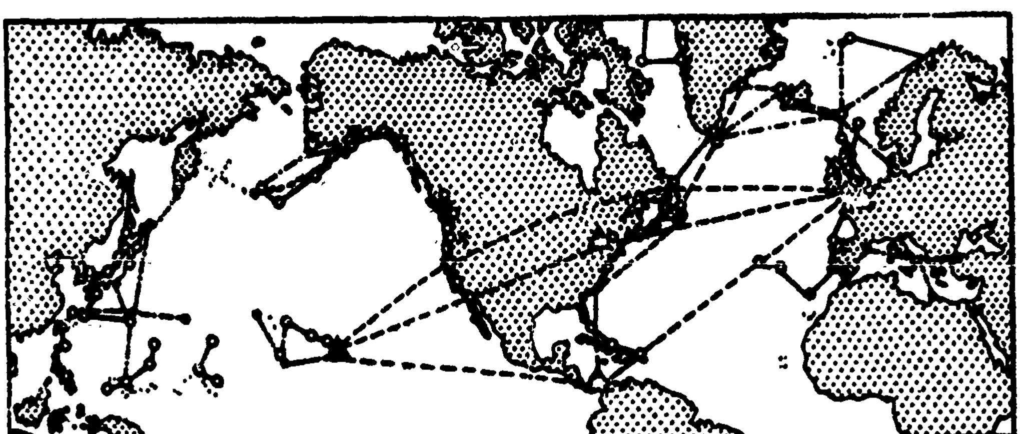
For facilitating the work of the navigator there have been developed light transistor airborne receivers on microcircuits with direct reading. It is possible to carry out continuous indication of the distance to the final point of the route and lateral deviation. Signals can be sent to the automatic pilot or ground-position indicator.

Taking into account that the zone of action of the "Loran" system does not cover the central and southern part of the North Atlantic large regions the Pacific Ocean and the whole southern hemisphere,

in the USA there has been developed a new phase hyperbolic navigation system "Omega," operating in the ultralong-wave bands. The tests of the system have been conducted since 1960, evaluation of the effectiveness has been conducted since 1961 in the U. S. fleet in the English aviation institute AE. There are four temporary stations (only for tests). The operating frequencies are from 10.2 to 13.6 kHz. With distribution of eight ground stations on the earth's sphere with power 10 kW each of the aircraft can determine its calculated ground position over any point of the surface of the planet.

The accuracy of determination of the aircraft ground position at a distance of 9300 km from a ground station is 1000 m by day and 2000 m at night. The coordinates of the aircraft ground position are given continuously. According to plans of the U. S. fleet, it was proposed to begin the construction of eight stations in 1966. Their planned cost is 100-120 million dollars.

Figure 41 shows the layout on the earth's sphere of stations of several American long-range radio navigation systems.



Legend

- ● Stations of "Loran A" system (chains are shown by solid lines)
- ▲ Stations of "Omega" system (broken lines)
- • Stations of "Loran C" system (dot-dash lines)
- ✖ Stations of "Console" system

Fig. 41. Distribution of American long-range radio navigation systems.

The tactical navigation system provides the crew a graphic image of the track of the aircraft and gives its coordinates relative to a certain point. On the "Orion" aircraft there are three aids for this. One of them is classified. The second, designated PT-396/A, is the "ground-position indicator," automatically plotting the track in coordinates X, Y for the navigator. The third OA-1768/A/A A-13 provides the same data for the pilot. Into the "ground-position indicator" a tactical coordination officer can input data on the coordinates of various objects (for example, the coordinates of buoys and so forth). Besides these instruments, the fliers and the tactical coordination officer have bearing, range and course indication (VDNI), which gives information about the true course, bearing and range to the target.

As reported by the "Journal Rritist R. A." (1962, No. 6), in a number of foreign countries, specifically in the USA, many works are conducted on the creation of new and the perfection of existing infrared instruments and systems of navigation aids of the aircraft. Specifically, there is developed airborne aircraft infrared equipment, using physical fields, created by heat radiation of objects located on the surface of sea and land. It is considered that in the future infrared technology will find wide application with the creation of astrotrackers.

Communication Means of Antisubmarine Aviation

Communication of antisubmarine aircraft is carried out with the aid of transceivers and superhigh-frequency subsystems AN/ARC-84 and AN/ARC-52, which are connected to the aircraft telephone system AN/AIC-22. The latter allows each crew member to listen to any receiver. To it are connected the airborne radio receivers of the submarine search and detection system, and also magnetic tape recorders.

In 1966 from Cape Kennedy with the aid of a "Titan" 3C carrier rocket there were launched seven military communication satellites and one research satellite with gravitational system of stabilization. All the satellites were inserted into a calculated equatorial, almost synchronous orbit at altitude 21,750 km.

However, not one of the named facilities provides direct communication of an aircraft with a submerged submarine. Therefore, abroad there are continued works directed toward searches for communication with submarines. It is proposed that they can be created on the principle of utilization of long and ultralong electromagnetic waves, and also with the aid of lasers.

Furthermore, according to a report of the periodical "Electronic News" 1966 (No. 24/1), in the USA there are conducted investigations of the possibility of utilization of so-called hydronic and plasmonic waves for communication of submarines with aircraft.

Airborne Means of Destruction of Submarines

Antisubmarine weapons, being in the armament of aviation in the years of the Second World War, turned out to be ineffective for combatting atomic submarines.

Judging by available reports, the efforts of foreign specialists, large firms and research laboratories of Navy were directed to the development of the following types of weapons of destruction: antisubmarine torpedoes, depth bombs, antisubmarine rocket torpedoes and mines.

Airborne Antisubmarine Torpedoes

Torpedo weapons continue to occupy a visible place among airborne weapons of submarine warfare.

Torpedoes began to be developed as the type of combat weapons of surface ships and submarines even in the period of the First World War. The airborne torpedoes started to be used only at the end of the war, but did not receive wide application.

After the Second World War into U. S. Navy armament were placed the following main types of torpedoes, which can be applied from airborne carriers: Mk43, Mk44, and Mk46. Each of these torpedoes has an acoustic homing system.

With respect to principle of guidance the homing torpedoes are active and passive. Active homing torpedoes send sound pulses. These pulses reach the target, are reflected from it and go back to the torpedo. The arrived echo through a special control system affects the torpedo rudders, guiding the torpedo directly to the target.

Passive homing torpedoes operate on the principle of a sound locator station, receiving noises coming from screw propellers and other operating mechanisms of the target ship. The received noises finally act on the rudders of the torpedo, guiding it to the target.

The torpedo Mk43 (Fig. 42) – torpedo with electric motor and acoustic homing system. It was accepted into the armament in 1957. Its weight is about 113 kg, length 2.43 m, diameter 254 mm, range 4600 m.

The torpedo can be released from aircraft, helicopters and airships. With such torpedoes the aircraft can land on the deck of an aircraft carrier. With release from an aircraft for slowing the fall of a torpedo and decrease of the force of impact into the water a parachute is used.

The torpedo Mk44 (Fig. 43) – a lightened electrical torpedo with acoustic homing system.

The model 1 Mk46 torpedo differs from the model 0 in the engine, which operates not on solid, but on liquid monopropellant. The main advantage of the liquid-propellant engine, according to the evaluation of foreign naval specialists, is its high economy.

Torpedo Mk46 pertains to the class of small lightened torpedoes. It weighs not more than 260 kg and can be used by aircraft, helicopters, including [DASh] (ДЭШ) (drone antisubmarine helicopter) unmanned systems.

In 1966 the firm Honeywell Ordnance Division delivered such torpedoes to the U. S. Navy for the sum of 52.4 million dollars, and in 1967 it was given an order for the sum of 12.5 million dollars.

Abroad considerable attention is given to the development of new models of torpedoes. For this goal, for example, in the USA, special programs of works are accepted under the general name "Retorc" I and II.

As one of the main assignments when developing torpedoes of the future foreign specialists consider the further increase of their speed, ranges and depths of travel. For this in electric torpedoes there are used alkaline silver-zinc storage batteries of increased capacity batteries, where as electrolyte there is used sea water, freely entering the torpedo, and the plates are made from magnesium and silver chloride. The development and introduction of batteries of the last type are considered by American specialists as the greatest innovation in the area of torpedo weaponry after the Second World War. The foreign press reports as if the new storage batteries with electrolyte from sea water are ten times lighter than equivalent lead-acid. The Americans are continuing the works of the Germans in the area of the application of heat engines, which operate on the Walter cycle, for high-speed torpedoes.

A constant requirement when developing torpedoes, considered abroad, is that the speed of the torpedo should be five times higher than the submarine being pursued by it. This means that for attacking a ship, moving at a speed of 30 kts, a torpedo with a speed of 150 kts is necessary. The torpedo must not only possess such a speed, but must also be noiseless, in order not to disturb the operation of its acoustic guidance instrument.

However, at speeds of motion over 50 kts on the housing and screw propellers appears cavitation, which is accompanied by lowering of the efficiency of propellers, increase of torpedo resistance and intensive noise emission. For elimination of this deficiency it is proposed to improve the contours of torpedoes and the shape of screw propellers, use torpedoes at depths greater than usual, to use hydrojet and rocket motors as torpedo engines and finally to use special coatings.

According to the press, U. S. Navy specialists are working on the creation of a torpedo with a speed of 100 kts. The experimental torpedo of the Aerojet firm with a jet engine of one of the newest types during testing reached an underwater speed of 155 kts. In essence this is no longer a torpedo, but an underwater rocket. However, at such a speed the noises of torpedoes are very considerable, which facilitates their detection by sonar means. Furthermore, torpedoes with jet engines and especially with solid-propellant engines have even shorter ranges. For torpedoes with speed of motion over 50-60 kts the application of new types of propelling agents is considered necessary.

With the creation of new models of torpedo weaponry abroad considerable attention is given to the development and improvement of various homing systems of torpedoes and their control systems. At present the most widespread are acoustic homing torpedoes with passive and active guidance systems. In the first case the sensing element of the system is a sound ranger, and in the second — sonar.

However, as yet they have not managed to create a sufficiently improved torpedo with an active system. The considerable noises, caused by the moving torpedo and especially by its propellers, interfere with the operating of acoustic homing systems of torpedoes. For improvement of their operating conditions in the USA there are being developed acoustic filters, which lower the interference level from the set noise of the torpedoes. Furthermore, most of the new homing torpedoes do not have reducing gears and other pinion drives.

For decrease of noises, being created by the engines, the latest U. S. acoustic torpedoes have one screw propeller, and not two, as torpedoes of old models. The replacement of pneumatic control actuators by electrical along with other advantages also lowers the noisiness of the torpedo to a certain extent.

In the area of development of remote-controlled torpedoes severe difficulties stand before the designers. For increase of the probability of target destruction torpedoes of some types are equipped with instruments, giving a maneuvering capability to the torpedoes within limits of a certain area according to a prescribed program (circle, spiral, zigzag, etc.).

An important improvement of torpedo weaponry was the creation of atomic charge separation, which increased the radius of destruction of the torpedo several tens of times.

Modern torpedoes have contact (for example, inertia) and proximity fuses. The latter includes fuses reacting to physical fields, being created by a ship (magnetic, acoustic, optical, etc.), and also creating a proper physical field and change reacting to it near the enemy ship (for example, electromagnetic).

Foreign naval specialists consider that a promising torpedo will have a casing of titanium or magnesium alloy with special jacketing to get a perfectly smooth surface. Its acoustic homing

system will operate at infrasonic frequencies. Such a torpedo will be equipped with atomic or conventional charge and will be able to have speed 150-200 kts.

It is noted, that an ultrahigh-fast torpedo can be created with the condition of application of a highly economical ram or pulse hydrojet engine on it. According to the American press, one of the versions of a solid propellant reaction engine is already available on the Mk46 torpedo.

Foreign specialists give considerable attention to the study of the possibility of application of the infrared (heat) principle in torpedo guidance systems.

Rocket Torpedoes

A further step in the development of antisubmarine torpedoes was the creation of airborne homing torpedoes with a jet projectile-torpedo carrier, which serves for increase of its flight range and considerable reduction of the time of travel of the torpedo to the target. A prototype of such a jet projectile of the "air-to-underwater target" class is so-called "flying torpedo" "Petrel" (Fig. 44), accepted into the armament in 1955. The basis of this rocket torpedo is a 609-mm antisubmarine homing torpedo, on which are mounted wings, control elements, a turbojet engine, which possesses thrust around 150 kg, and a combined guidance and homing system. The "Petrel" torpedoes are launched from under the wings of an aircraft.

At the end of 1957 by command of the U. S. Navy an order was given for the manufacture of an experimental batch of the improved antisubmarine rocket torpedo of type Dove AVW-N. This rocket torpedo was equipped with an infrared homing head and was developed in two versions: AVN and AVW-5. In connection with the development of these improved antisubmarine rocket torpedoes further production of the "Petrel" was ceased. There are reports that work on Dove rocket

are also ceased, and the "Petrel" rocket has been removed from the inventory. This indicates the ineffectiveness of rocket torpedoes and the serious technical difficulties, which arose during the creation of this weapon. But, despite these difficulties, the U. S. Navy is investigating the question of creation of a new missile of the "air-to-underwater target" class for utilization from antisubmarine patrol aircraft. The rocket will be fired after the detection means installed on the aircraft fix the location and the character of the underwater target.

Fig. 44. Rocket torpedo "Petrel."

Depth Bombs

Depth bombs are considered another basic type of contemporary aerial means of destroying submarines. Therefore, along with the development of antisubmarine torpedoes and guided projectiles considerable attention is given to the perfection of antisubmarine aerial bombs.

Being in the armament of antisubmarine aviation of foreign governments, aerial bombs are subdivided into small and large, high-altitude, in which a hydrostat is applied as a fuse, and "skimming,"

releasable from low-level flight and having proximity fuses. Furthermore, they are subdivided with respect to the type of explosive charge into nuclear (atomic) and conventional.

Atomic bombs are a further development of antisubmarine bombs. In 1956 in the course of tests of new types of atomic antisubmarine weapons conducted on the Pacific Ocean by the Unites States of America there was produced, specifically, an underwater atomic explosion at a depth of 60-150 m. Using experimental data as a base, U. S. naval specialists arrived at the conclusion that by means of an underwater atomic explosion, even of relatively low power, it is possible to destroy a submarine at a distance from ground zero almost 100 times exceeding the damage radius of the submarine by a conventional depth bomb.

According to reports of the American press, the experimental explosions allowed revealing some tactical features of the new antisubmarine weaponry. For example, a small atomic bomb with TNT equivalent 2500 t during an explosion at a depth of 30 m can destroy a submarine located at a depth of 60 m and at a distance of 600 m from ground zero. Furthermore, the damage radius is increased with increase of depth of the atomic bomb explosion. Therefore, submerging the submarine to a great depth for the purpose of increase of safety from atomic bombs does not reduce, but on the contrary increases its vulnerability.

When using atomic depth bombs against submarines, operating in regions with depths less than 90 m, the damage radius of the submarine is diminished and can be only about 0.4 of the maximum possible damage radius. It is considered that atomic depth bombs do not replace, but supplement antisubmarine weaponry of conventional types, however, they will have a substantial effect on submarine tactics.

At present in the U. S. Navy two types of atomic depth bombs exist: "Betty" and "Lulu."

"*Betty*" – depth bomb with nuclear charge, equivalent to 10 kt of TNT, entered the inventory of U. S. antisubmarine aviation in 1957. The destruction radius of this bomb at a depth of 30 m reaches 1000 m and at a depth of 150-1600 m. The bomb is used only for aircraft.

"*Lulu*" (Fig. 45) – small depth bomb with nuclear charge, equivalent to 2.5 and 10 kt of TNT. Its weight is 550 kg, i.e., almost three times lighter than the atomic bomb "Betty." The destruction radius of the "Lulu" at a depth of 60 m is about 600 m. For comparison let us point out that with an explosive charge of conventional type weighing 150 kg the depth bomb has a destruction radius only up to 8 m.

Fig. 45. Overall view of atomic depth bomb "Lulu."

The atomic bomb "Lulu" can be used by land- and carrier-based aircraft and helicopters.

Although abroad depth bombs with nuclear charges are publicized in every way possible, nevertheless foreign specialists consider that the application of these bombs will be limited. Their utilization

will be possible only in case of an atomic war. Furthermore, it is not possible to use these bombs in straits, near a coast or in the region of location of ships and convoys being escorted. At the same time it is considered that an atomic depth bomb gives the aircraft large combat power and therefore is considered by foreign specialists as a means of antisubmarine defense of a region. Bombs and rockets are hung in a pressurized bomb bay, located on the bottom in the forward section of the fuselage of an aircraft. Usually they will be released by the pilot, but if necessary they can be released by the tactical coordination officer.

Antisubmarine Mines

Besides the noted means of destruction, in the inventory of foreign antisubmarine aviation there are mines, intended for laying in coastal regions, in harbors and on roads of the enemy. They continue to remain in the arsenal as a means of destruction of submarines. American naval specialists consider that in the offensive combat operations of NATO countries the utilization of antisubmarine mines will have important value, since with their aid in several hours from the air the main passages, through which the enemy should deploy his submarines can be mined.

Therefore, in postwar years abroad sufficient attention was given to the development of mine weapons. An antisubmarine mine as is known, — stationary or self-propelled projectile under certain conditions, placed underwater for destruction of submarines, entering its effective zone. All the antisubmarine mines with respect to position after laying are subdivided into anchored, bottom and floating (drifting).

The most improved mines are considered anchored, possessing special homing instruments. Such mines with the approach of a submarine at a certain distance are disconnected from the cable or come to the surface from the ground and similar to a guided torpedo with acoustic fuse move toward the target. It is proposed to place them in the most probable paths of movement of submarines.

Aerial mines, being in the armament of antisubmarine aviation of countries-members of NATO, include bottom mines Mk52, Mk55 and anchored mine Mk56. The mine Mk52 weighs 1000 pounds (450 kg), and Mk55 and Mk56 – 2000 pounds (900 kg).

All these types of mines possess increased impact strength, because of which they can be released from high altitudes.

The further development of antisubmarine mines goes toward increase of the reliability of separate nodes, simplification of construction and reduction of cost of their industrial manufacture. Special attention is given to mines, suitable for laying from aircraft, flying at high speeds. Specifically, aerial mines Mk52 and Mk55 are improved in this direction.

CHAPTER III

ORGANIZATION AND FUNDAMENTALS OF APPLICATION OF THE ANTISUBMARINE AVIATION OF CAPITALIST COUNTRIES

Organization of Naval Antisubmarine Aviation of Capitalist Governments

U. S. Navy Antisubmarine Aviation

The organization of U. S. Navy antisubmarine aviation is characterized by many present and quite stable traditions, which were formed and tested as early as in the course of the Second World War.

The composition of U. S. Navy antisubmarine aviation includes:

— antisubmarine carrier-based (deck) aviation;

— land-based aviation;

— DASH weapons system — antisubmarine helicopters of destroyers, frigates, destroyer escorts which entered the ASW system and the organization and equipment structure of ships.

Antisubmarine carrier-based (deck) aviation. At the end of fiscal year 1965/66 the composition of the U. S. Navy included nine antisubmarine aircraft carriers. In 1966 their quantity was decreased to eight (four each in the Atlantic and Pacific Oceans).

This number of antisubmarine aircraft carriers was kept to fiscal year 1968/69.

Under ordinary conditions on an antisubmarine aircraft carrier there is based an aviation group, which has in its composition (in terms of equipment) two squadrons of Grumman S-2D "Tracker" carrier-based antisubmarine aircraft with 10 aircraft for each squadron; one squadron – 14-16 Sikorskiy SH-3A or SH-3D "Sea King" antisubmarine helicopters; a detachment – four radar picket aircraft of type E-1B "Tracer."

Recently the naval leadership of the USA has recognized it as necessary for strengthening the air defense system to have a detachment – four "Skyhawk" fighters on each antisubmarine aircraft carrier.

Land-based aviation. The basic unit of land-based patrol (antisubmarine) aviation is the wing. The composition of a wing includes several patrol squadrons, each having 10-12 patrol aircraft.

The armament of the 27 patrol (antisubmarine) squadrons consists of Lockheed P-3A "Orion" and Lockheed P-2 "Neptune" aircraft.

As is proposed, in the future these aircraft will be replaced by the Lockheed P-3C "Orion."

The composition of land-based aviation up to the autumn of 1967 included obsolete Martin P5M-2 "Marlin" flying boats, which have long been removed from production, and at present from the inventory.

Units of land-based aviation (squadrons) enter the composition of naval districts and are operationally subordinate to the district commanders or, where there are more, to operational unit commanders.

The commander of U. S. Naval Aviation and his staff mainly direct special preparation and supply. All problems of combat application are solved by the appropriate commanders of naval districts and operational units.

With modernization according to the FRAM (fleet rehabilitation and maintenance) program old destroyers, built during the past war, were armed with radio-controlled antisubmarine helicopters of the DASH system. Toward the end of 1966 in all there were modernized destroyers of class "Gearing" 83 units, "Carpenter" – 8 units, "Allen M. Sumner" – 34 units and frigate "Mitscher" – 4 units.

Since the autumn of 1962 the USA has widely expanded the building of new destroyer escorts. In all there was provided a program to build 52 ships (part of them is already constructed). They include 10 "Garcia" class (total displacement 3400 t), 6 "Brook" class (total displacement 3425 t), 36 "Knox" class (total displacement 4100 t). All the ships can develop speed up to 27 kts.

On all ships there is installed the same type of antisubmarine armament: 1 PLUR (antisubmarine guided missile) "Asroc" and 2 three-tube torpedo devices. Ships of the "Garcia" and "Brook" classes will have in the armament two radio-controlled helicopters each, and on ships of the "Knox" class – even three of such helicopters.

One should bear in mind that the organizational structure, adopted in U. S. antisubmarine aviation, for the overwhelming majority of allied or simply dependent (making up the content) capitalist countries is the standard for imitation.

Antisubmarine Aviation of the British Navy

Obediently following the aggressive politics of the USA, Great Britain, although she builds atomic missile submarines, nevertheless, judging by the many statements of English military and naval specialists in the press, as before gives considerable attention to

the oldest and acute problem for the British Islands, the protection of sea trade.

While in the USA the main problem in prepared measures of antisubmarine warfare — active warfare against atomic missile submarines, the Navy of Great Britain accentuates the antisubmarine defense of formations of combat ships and especially transports on crossing by sea, which in many respects determines the character of development, organization, composition of forces and facilities of aviation for antisubmarine warfare.

The first aircraft for combatting submarines in the composition of the naval forces of Great Britain appeared in 1914, and English naval aircraft for the first time in history destroyed a German U-boat.

In the course of the past war there was formed a unique organization of English aviation for combatting submarines, which was kept until now.

Unlike the U. S. Navy, where on attack aircraft carriers there are no aircraft or even helicopters for search and destruction of submarines, on British aircraft carriers there are squadrons of deck-based antisubmarine helicopters.

In the beginning of the sixties the Navy of Great Britain recognized that antisubmarine helicopters can sufficiently solve the problem of PLO (antisubmarine defense) of aircraft carriers, since according to the conviction of English specialists, helicopters have the highest effectiveness in conducting antisubmarine search. They are able to effectively destroy submarines, inasmuch as they attack from short distances without risk of countermeasures. From the station aircraft "Gannet" A.S.Mk1 and A.S.Mk4 are converted into deck-based picket aircraft ("Gannet" A.S.Mk3). Thus, for instance, already in the first half of 1963 on the aircraft carrier "Ark Royal" as an air group, besides squadrons of attack aircraft and fighters and a detachment of "Whirlwind" rescue helicopters, there was the 849th squadron of "Wessex" antisubmarine helicopters.

In 1966 after re-equipping, the attack aircraft carrier "Hermes" entered the formation. On it are based: squadron of "Buccaneer" Mk2 attack aircraft, squadron of "Sea Vixen" fighters and a squadron of "Wessex" antisubmarine helicopters.

In Great Britain, just as in the USA, it is considered that for a substantial increase in the combat capabilities of destroyer escorts - the main antisubmarine ships for combatting submarines - it is necessary to arm them with antisubmarine helicopters. But in Great Britain, unlike the USA, for antisubmarine ships there has been adopted the MASH (manned antisubmarine helicopter) weapons system and respectively a manned helicopter. They make up the armament of destroyer escorts of the "Tribal" and "Leander" classes. This pertains not only to old destroyer escorts, built in the course of the Second World War, but also those constructed according to program of recent years.

Thus, for instance, on the latest destroyers of the "County" class (Fig. 46) there are provided a takeoff and landing platform, a winch and other equipment for basing and application of Westland "Wasp" A.S.1 antisubmarine helicopters.

Fig. 46. Guided-missile destroyers "London" and "Kent" – carriers of manned antisubmarine helicopters of Westland "Wasp" type, Great Britain.

In the composition of the land-based air forces of Great Britain there is the Coastal Aviation command, the main duty of which in peacetime is to conduct daily reconnaissance of the ocean, and also detection, pursuit and when necessary destruction of submarines and surface ships of the enemy. Organizationally the coastal command has several squadrons of patrol (antisubmarine) aircraft. Operationally, as during the Second World War, the coastal command is subordinate to the Admiralty.

Antisubmarine Aviation of the Navy of Canada.

In accordance with the operational and strategic plans of NATO Allied Naval Forces the main missions of Canadian Naval Forces in war will be:

- antisubmarine defense of the North American coast on the Atlantic and Pacific Oceans;

- protection of sea communications in the American-Canadian region of NATO.

Perspectives of the operational and strategic utilization of the Canadian Navy, as an antisubmarine fleet, predetermined that all its ships and sea aviation are constructed and armed mainly for submarine warfare.

As can be judged by materials of the foreign press, an antisubmarine directivity determines the content and the five-year program (1965-1970) of development of the Navy of Canada.

A characteristic feature of development of Canadian naval aviation after the Second World War is that the overwhelming part of its aircraft and helicopters was either purchased in the USA under bondage conditions, or built at aircraft manufacturing plants in Canada, but under licenses acquired from American firms.

Since January of 1966 all the antisubmarine defense forces of the Navy and Air Force of Canada have been subordinate to the commander of antisubmarine forces of the Atlantic and Pacific Oceans (he is the commander of navial aviation) located in Halifax.

At the end of 1966 the Canadian naval aviation consisted of 72 CS2F-2 "Tracker" aircraft and several dozen antisubmarine helicopters of types CHSS-2 "Sea King," HTL-6 "Bell" and HO4S-3 Sikorskiy. Furthermore, there is a certain quantity of coastal based heavy patrol (antisubmarine) aircraft Canadiar CL-28 "Argus."

One squadron of antisubmarine aircraft (12 "Tracker") and a squadron of antisubmarine helicopters (8 "Sea King") are based on the antisubmarine aircraft carrier "Bonaventure" (Fig. 47). A squadron of coastal-based antisubmarine CS2F-2 "Tracker" aircraft are located at the Patricia Bay airfield (in the region of the city of Victoria) on the Pacific coast. The remaining squadrons of carrier-based and coastal-based antisubmarine aviation are assigned to the naval base Shearwater on the Atlantic coast.

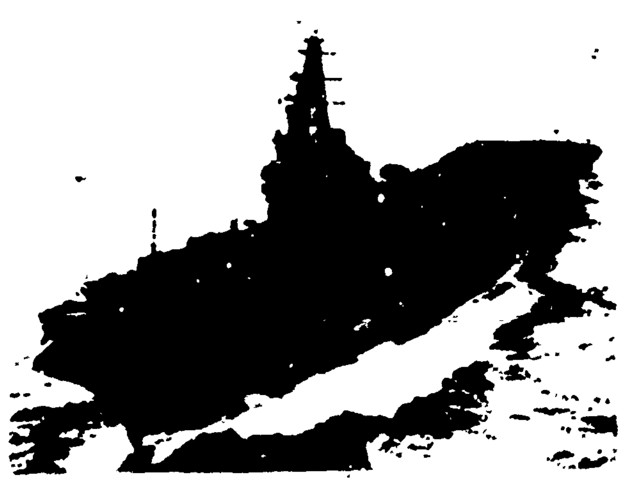


Fig. 47. Antisubmarine aircraft carrier "Bonaventure," Canada.

As in Great Britain, the armament of destroyers and destroyer escorts of the Canadian Navy consists of manned antisubmarine helicopters.

Thus, on each of the four DDH class destroyers (total displacement 3800 t, speed 27 kts) planned for construction it is proposed to have two manned antisubmarine helicopters each.

On two destroyer escorts of the "Annapolis" class (total displacement 2900 t, speed 27 kts) and seven destroyer escorts of the "St. Laurent" class (total displacement 2800 t, speed 28.5 kts) there is one manned antisubmarine helicopter on each ship.

It was reported that on the destroyer escort "Margaree" ("St. Laurent" class), introduced into the regular fleet, there was provided a takeoff-landing platform for the "Sea King" type antisubmarine helicopter.

The tactical-technical characteristics and combat capabilities of the CS2F-2 "Tracker" aircraft and CHSS-2 "Sea King," HTL-6 "Bell" and HO4S-3 Sikorskiy helicopters are similar to those making up the armament of the U. S. Navy.

Antisubmarine Aviation of the French Navy

The antisubmarine aviation of the French Navy includes carrier-based antisubmarine aircraft and helicopters, and also coastal-based antisubmarine aircraft.

In a lecture, dedicated to questions of the development of naval forces, the Chief of Staff of the French Navy, Admiral J. Cabanet in 1965 reported that in 1970 the French Navy will have 2 aircraft carriers, 116 antisubmarine aircraft (38 "Atlantic," 18 P2V-7 and 60 Breguet 1050 "Alize'") and 20 antisubmarine helicopters "Super Frelon." At present the armament consists of Sikorskiy SH-34 helicopters.

Judging by the series of exercises of NATO allied naval forces, which occurred up to 1967, in which the antisubmarine forces of the French Navy, including antisubmarine aviation, took part, with respect to their operational mission they were considered only as a supplement to the numerically superior antisubmarine aviation forces of the USA.

The antisubmarine aviation of the French Navy includes deck-based (carrier-based) antisubmarine aviation (aircraft and helicopters); coastal-based antisubmarine aviation.

At present the composition of the French Navy includes the antisubmarine aircraft carrier "Arromanches."

The light aircraft carrier "Arromanches" (displacement 14,000 t) was obtained from Great Britain in 1946. In 1958 its complete overhaul was finished, in the course of which the aircraft-carrier was equipped with an angular flight deck, arranged at a 4° angle to the diametric plane. It can accomodate only 24 antisubmarine aircraft and helicopters, including Breguet 1050 "Alize'" type aircraft.

With respect to its aviation equipment the aircraft carrier "Arromanches" is better than English: considerably larger hangars, a longer catapult, the capability of catapulting aircraft weighing up to 20 t. Of the 30 aircraft, making up the standard capacity of the aircraft carrier, there are provided 10 Breguet 1050 "Alize'" antisubmarine aircraft.

At the beginning of 1966 the composition of carrier-based antisubmarine aviation included three flotillas of antisubmarine aircraft. Breguet 1050 "Alize'," three flotillas of antisubmarine helicopters Sikorskiy HSS-1 and the forming of a new flotilla of SA-3210 "Super Frelon" helicopters was planned.

Land-based antisubmarine aviation consists of five flotillas of Lockheed P2V-7 "Neptune" aircraft and one (again being created) flotilla of Breguet 1150 "Atlantic" aircraft.

In France the first steps have been taken for the armament of destroyers of the "Surcouf" class with antisubmarine helicopters.

Antisubmarine Aviation of the Japanese Navy

In the postwar period Japan became the leading supply base of American troops in the Korean War, and the ports of Japan – the supporting supply points of the U. S. Pacific Fleet. And now the Japanese capitalists by deliveries of materials, aviation gas, by repair of aircraft equipment and by other "services" substantially assist the USA in their criminal war against the people of Vietnam.

Several years after the signing of the unconditional surrender pact Japan with the assistance of the USA began to reactivate its naval fleet, and its sea aviation. Its primary missions are patrolling the sea region adjacent to Japan and providing antisubmarine defense of Japanese commercial navigation and ships of the naval fleet. At present behind the official designation of the self-defense fleet, which, incidentally, is widely publicized in the USA, it is simple to examine the increasingly expanding relations of the U. S. Navy with the Japanese fleet and the growth of the role of the latter in the system of antisubmarine defense measures on the Pacific Ocean, being prepared and conducted by the USA.

Now Japanese naval aviation consists of five aircraft wings:

1st wing (in Kanoya) made up of one squadron of P-2H "Neptune" patrol aircraft;

2nd wing (in Hatinoe), which includes two squadrons of P-2H "Neptune" patrol aircraft and a squadron of S-2A "Tracker" antisubmarine aircraft;

3rd wing (in Tokushima), consisting of two squadrons of S-2A "Tracker" antisubmarine aircraft;

4th wing (in Shimoasō) made up of one squadron of P-2H "Neptune" patrol aircraft, one squadron of S-2A "Tracker" antisubmarine aircraft and a flight test squadron;

21st wing (in Tateyama), consisting of one squadron of SH-34 "Seabat," SH-3A "Sea King" and UH-19 antisubmarine helicopters.

One squadron of antisubmarine helicopters each is based at Komatsushima and Ōminato.

The air training command of the Navy (with headquarters in Utsunomiya) has a detachment (In Kanoya), where in the final phase of instruction the fliers are trained with P-2H "Neptune" combat patrol aircraft and S-2A "Tracker" combat antisubmarine aircraft.

At the end of 1965 Japanese naval numbered about 120 patrol and antisubmarine aircraft and antisubmarine defense helicopters.

Fig. 48. Shin Meiwa patrol seaplane PX-S.

According to the third plan of construction of the armed forces it is projected to order 90 new patrol aircraft, including 69 modified

P2V-7 aircraft, developed by the company "Kawasaki" on the basis of the P-2H "Neptune," and 22 PX-S flying boats of the company "Shin Meiwa" (Fig. 48). The SH-34 "Seabat" helicopters are being replaced by SH-3A "Sea King." At the end of fulfillment of the third plan of construction of the armed forces the naval aviation will receive 60 SH-3A "Sea King" helicopters.

Antisubmarine Aviation of the Italian Navy

The Italian Navy in the composition of coastal-based antisubmarine aviation has about 50 Grumman S-2A "Tracker" aircraft. On a number of ships of the "destroyer-destroyer escort" class the utilization of antisubmarine helicopters is provided.

Antisubmarine Aviation of the Dutch Navy

The Navy of the Netherlands includes coastal-based antisubmarine aviation, the armament of which consists of aircraft and helicopters, purchased in the USA.

At the beginning of 1966 the naval antisubmarine aviation included one squadron of P-2H "Neptune" aircraft, two squadrons of S-2A "Tracker," one squadron of SH-34 "Seabat" antisubmarine helicopters, based at an airfield in the region of Falkenberg. Furthermore, one S-2A "Tracker" squadron is based on Curacao Island.

According to reports of the press, the armament of "Van Speijk" class frigates, under construction, consists of a light manned antisubmarine helicopter.

Antisubmarine Aviation of the New Zealand Navy

Of the five P-3B "Orion" aircraft ordered from the Lockheed firm at the beginning of 1966 New Zealand received one aircraft, and at

the end of the year the remaining. These aircraft are intended for replacement of the obsolete "Sunderland" aircraft of the reconnaissance squadron. The P-3B "Orion" aircraft have antisubmarine armament.

Antisubmarine Aviation of the Australian Navy

The Australian Navy has a coastal-based reconnaissance squadron, the armament of which includes Lockheed P-3A "Orion" aircraft with the complete set of antisubmarine armament. Furthermore, there is a squadron of S-2D "Tracker" aircraft for utilization on the aircraft carrier "Melbourne."

The aircraft carrier "Melbourne" (total displacement 20,000 t) with total capacity of 35 aircraft in its air group has one squadron (8-12 aircraft) of antisubmarine aircraft and one squadron (up to 16 of the "Wessex" type) of antisubmarine helicopters.

Antisubmarine Aviation of the West German Navy

In recent years the West German Navy has rapidly developed the antisubmarine aviation, the basis of which is a squadron of Breguet 1150 "Atlantic" antisubmarine aircraft.

Fundamentals of Application of Antisubmarine Forces

Reports published in the foreign press on the character of combat training and the volume of exercises conducted by NATO countries testify to the fact that the naval forces of the USA, Great Britain and other imperialistic governments are prepared for conducting aggressive offensive actions against submarines under conditions of various military-geographic and operational-tactical situations.

The leadership of the U. S. armed forces considers enemy submarine warfare as a national problem and one of the most important strategic missions of U. S. naval forces in a future war against the USSR and other coutries of the camp of socialism. It is proposed to solve this most important, in their opinion, strategic problem by *applying the forces of the allied strike fleet of powerful nuclear strikes* on the locations of basing, repair and building of submarines of the Soviet Union.

"Strategists" of NATO allied naval forces consider that during massed strikes by forces of carrier-based strike formations and submarines-rocket carriers there will be a strong reaction to them on the part of Soviet submarines, which can lead to substantial losses among the aircraft carriers and atomic submarines and, above all, does not exclude the disruption of planned strikes. The latter obliges, as considered in the leading naval circles of the USA, having rather powerful antisubmarine forces, including aviation for antisubmarine defense of carrier-based strike formations on crossing an ocean and in the maneuvering region during combat operations of carrier-based strike aviation.

Although American admirals attach great importance to the operations of carrier-based formations on the destruction of submarines at their bases, at the same time they consider that a considerable part of the submarines, deployed earlier in regions of combat patrolling, can avoid the strikes and will be immediately used for a powerful retaliatory strike on key strategic objects of the USA and their allies both on the American and on other continents and islands. For this very reason the men of the Pentagon provide for:

— *the creation of powerful intercepting antisubmarine barriers* on all probable paths of breakthrough of Soviet submarines into the regions of their combat operations, at approaches to the coast of North and South America;

— *the organization of daily active combat operations on search and destruction of submarines* in the most dangerous regions of the world's ocean, and also direct antisubmarine protection of formations of combat ships and convoys in the ocean.

Incidentally, antisubmarine barriers were created by the English as early as the First World War.

For search and destruction of submarines the Americans propose to apply antisubmarine forces in the composition of three types of operational antisubmarine groups.

1. Air patrol, which includes antisubmarine aircraft, conducting the search and attack of detected submarines in coastal regions, and also operating stationary systems of long-range detection of underwater targets at antisubmarine barriers.

2. Patrol destroyers and destroyer escorts. They supplement the air patrol with conducting antisubmarine defense of ocean communications, operating in convoys. On the majority of U. S. destroyers, frigates and destroyer escorts there will be used unmanned and light manned helicopters.

3. Carrier-based hunter-killer antisubmarine groups (APPUG), which include an antisubmarine aircraft carrier and 6-8 destroyers (frigates, destroyer escorts). The APPUG can be supported by forces of land-based aviation and antisubmarine submarines, including atomic antisubmarine submarines, equipped with the latest electronic equipment for search and identification of submarines and modern weapons for destruction.

In view of the specific qualities and capabilities which antisubmarine submarines possess, they are considered the basis of offensive forces in antisubmarine operations. Enormous importance in antisubmarine operations is attached to the participation of heavy

land-based (patrol) and carrier-based antisubmarine aircraft, manned and radio-controlled helicopters.

Besides the antisubmarine forces of the USA, Great Britain, Canada, FRG, Italy, Japan, and Australia, the American leadership of naval forces proposes the extensive use of fleets of many South American Governments more devoted to the USA, to which falls considerable "disinterested" aid to the equipment of antisubmarine forces, primarily antisubmarine aircraft and helicopters.

In the fifties in the USA and NATO allied naval forces the position was firmly determined that the operational and tactical interaction of mixed antisubmarine forces is the basic principle of their utilization in antisubmarine operations and when solving particular problems of antisubmarine warfare.

Namely, in the opinion of American specialists, the positive qualities of antisubmarine forces and weakening of the negative effect of possible deficiencies should find their best application in the interaction of surface ships, submarines and antisubmarine aviation.

The practice of numerous exercises on antisubmarine warfare of fleets of the USA, Great Britain, Canada and NATO allied naval forces confirms that organization and control of the interaction of mixed antisubmarine warfare forces – the basic content and the purpose of all exercises. Large value is attached to the secrecy of preparation for antisubmarine operations, so that the enemy would not know from where and by what means the strikes will be inflicted. Each strike, inflicted on him, should be sudden. The character and probable forms of utilization of antisubmarine aviation in interaction with other antisubmarine warfare forces can be traced in many means, enormous in span and expenditures, of measures for preparation and equipment of the theatre of war operations for conducting antisubmarine war.

Antisubmarine Barriers

An antisubmarine barrier, according to views of American naval specialists, — this is a complex of stationary systems and mobile means of detection and classification of underwater targets, and also the grouping of maneuvering forces, which are in the necessary combat readiness, able to establish and maintain contact with an identified submarine and, if necessary, destroy it within the zone being defended. In the composition of these forces for submarine warfare the leadership of the U. S. and British Navies uses antisubmarine surface ships, aviation and submarines.

The U. S. Naval Command planned the creation of antisubmarine barriers and at present their accelerated additional equipping is conducted at all outlets from the North Arctic Ocean, Barents and other polar seas through straits into the Atlantic and Pacific Ocean. Special attention is given to the creation of antisubmarine barriers at outlets to the northern part of the Atlantic Ocean, through which lie the basic paths between the ~~USA, their~~ NATO allies and most important in the opinion of Americans, the Central-European theatre of military operations. From materials of the foreign press it is known that the creation of the antisubmarine barriers is planned in the following regions (Fig. 49). Figure 49 is taken from the book of N. I. Suzdalev "Submarines Versus Submarines," Voyenizdat, 1968.

Eastern barrier — between northern Norway and the archipelago Spitsbergen. On this antisubmarine barrier the U. S. Navy command intends to exert reaction to submarines by maneuverable forces: land-based antisubmarine aircraft and antisubmarine submarines. It is considered that the application of positioned means for destruction of submarines at the given barrier is difficult because of severe weather conditions. Apparently, there is not excluded the possiblity of application of stationary means of submarine detection.

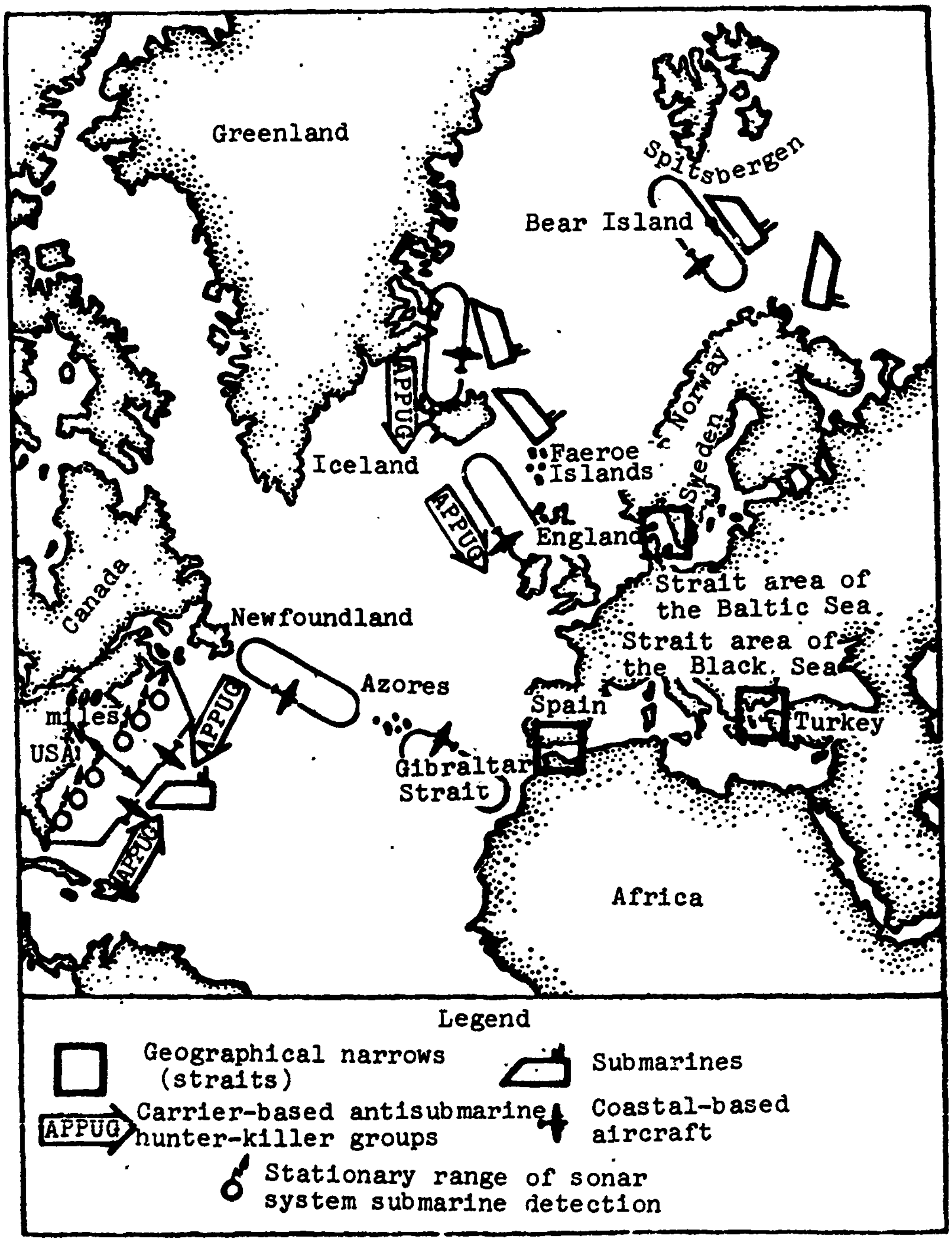


Fig. 49. Diagram of the location of antisubmarine barriers on the Atlantic Ocean.

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It is assumed that the basic form of application of coastal-based antisubmarine aircraft will be patrolling at the barrier.

The main, of as it is frequently called in the press — "western," antisubmarine barrier, is being prepared on the line Greenland-Iceland-Faeroes and Shetland Islands-sothwestern coast of Norway. Namely on this boundary it is proposed to create the strongest countermeasure to the entrance of Soviet submarines into the Atlantic.

American specialists consider that the great depths in the region of the boundary, varying from 200 to 1000 m, and also the strong strait-ebb currents, which reach 7 kts in the Spring,[1] exclude the possibility of widely applying all systems of the positioned antisubmarine means of obstruction and hamper the creation of continuous mine fields. The difficulties in the application of mine weapons on the western barrier also involve the fact that for providing at least a 50% probability of encounter of a submarine with one mine, even without allowing for cutting of mine fields from storms, only between Iceland and Shetland Islands there would be required to lay about 1 million mines. Incidentally let us note that in the Second World War on all sea theatres there were layed 640 thousand sea mines. Besides the large expenditure of resources and the time for laying mine fields, they cannot be layed secretly. Some American specialists have spoken doubts about the possibility of creation of continuous mine fields on the entire boundary.

Nevertheless the U. S. Navy command, as reported in the foreign press, proposes the creation of mine fields, but mainly on some of the most probable routes of travel of enemy submarines. Where it is not possible to create mine fields, it is planned to use maneuverable forces extensively, which include land-based antisubmarine aircraft, carrier-based antisubmarine hunter-killer groups (APPUG), antisubmarine surface ships and antisubmarine submarines.

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[1]Spring — the general name of two phases of the Moon — new moon and full moon, when the Sun, Earth and Moon are located approximately on one line. Tides reach the highest in the Spring.

Low temperatures in winter facilitate icing of antisubmarine ships and aircraft, frequent storms in autumn and winter periods with rain and snow limit visual observation, and overcast for almost a year considerably lowers the effectiveness of combat utilization of maneuverable forces. But, despite the unfavorable climatic and natural conditions, namely in this region the U. S. and their NATO allies intend to conduct antisubmarine warfare by strikes of maneuverable forces, including antisubmarine aircraft and mines, to bar the way to enemy submarines as reliably as possible.

Coastal antisubmarine belt. It is planned to cover long-range approaches to the American continent from the Atlantic Ocean by enemy submarines with constant patrolling of antisubmarine aircraft and destroyer escorts, carrying helicopters, on the line Newfoundland-Azores-Gibraltar Strait.

The object of special concern of the American military command is organization of warfare against enemy submarines-rocket carriers directly at close approaches to the Atlantic Coast of the USA.

According to reports of the foreign press, here a coastal "antisubmarine belt" is created with depth up to 600 miles. Even now in the area of this "antisubmarine belt" ships and antisubmarine aircraft, radar picket forces constantly patrol, and during complications of the international situation these forces are increased by antisubmarine submarines and aircraft.

Evaluating the prospective capabilities of atomic submarines-rocket carriers, U. S. naval specialists consider that the 600-mile depth of the antisubmarine belt along the eastern and western coast of the USA is clearly inadequate.

In order to hamper the combat activity of enemy submarines-rocket carriers, the U. S. Navy command increases the depth of the coastal antisubmarine barrier by means of creation of special systems of long-range detection and classification of underwater targets.

As was reported in the foreign press, in 1959 the American naval command proceeded toward the creation of a special complex of sonar and computer equipment, known under the name of project "Artemis." It is assumed that the "Artemis" complex will be used in conjunction with the operational system "Caesar," NATO hydrometeorological vessels and ships located at antisubmarine barriers.

In the "Artemis" complex there are used powerful sonic generators and high-sensitivity receivers.

The American antisubmarine warfare specialists consider that with final completion of the "Artemis" complex there will be created a fully modern system for detection of submarines, tracking them and guidance of antisubmarine aircraft to them and other maneuverable antisubmarine forces and coordinations of their operations on antisubmarine barriers in the entire North Atlantic.

In the overall complex of means for combatting enemy submarines on antisubmarine barriers in the Atlantic Ocean it is also proposed to extensively use carrier-based antisubmarine hunter-killer groups. American specialists consider that the APPUG, which includes mixed maneuverable antisubmarine forces, is the most acceptable form of organization of antisubmarine warfare forces on boundaries, and also in open regions of the world's ocean, as was the case during the Second World War. At present the U. S. maneuvering forces, intended for operations on antisubmarine barriers in the Atlantic Ocean, are represented by three operational units: 81st, 82nd and 83rd. The 81st operational unit should mainly conduct warfare against enemy submarines at near approaches to the Atlantic Coast of the USA. Since 1958 the composition of this unit has included the carrier-based hunter-killer groups "Alpha," "Bravo" and "Charlie."

Range approaches to the Atlantic Coast of the USA are screened from enemy submarines by the 80th operational unit.

The 82nd operational unit is a formation of barrier forces, intended for combatting enemy submarines on the main antisubmarine barrier of the Atlantic Ocean: Greenland-Iceland-Faeroes Islands-Shetland Islands-southern part of Norway.

For providing the operations of land-based antisubmarine aircraft in the Atlantic Ocean there have been created and are already being used aircraft bases Annejya [Translator's Note: unable to find in sources], Sola and Bod (Norway), Keflavik (Iceland), Aldergrove (Ireland), Kinloss (Scotland), Argentia (Newfoundland), Lagens (Azores Islands), Rota (Spain).

In the press it was reported that at these bases there are constantly found Norwegian, American and English antisubmarine aircraft. During exercises by NATO allied naval forces and in the period of an aggravated international situation the number of American antisubmarine aircraft at the airfields of Iceland and Norway is usually increased. Furthermore, for combatting submarines in Norwegian, Greenland and Barents Seas, and also at approaches to the coast of Great Britain and Portugal it is proposed to use English Aircraft from the airfields of Wales and Gibraltar and Portuguese aircraft from the Lisbon airfield. The large number of civil airfields in the coastal band in Western Europe, Great Britain, Ireland, Iceland and Norway creates the possiblity of concentration of considerable forces of land-based antisubmarine aircraft.

Antisubmarine warfare in the strait zone. The USA and their NATO allies assign an important place to the organization of antisubmarine barriers in the Baltic and Black Sea strait zones for countering the breakthrough of enemy submarines from the Black into the Mediterranean Sea, and from the Baltic into the North Sea, and then into the strait zone of the English Channel and into the Atlantic.

The American and English Naval Command studied the possibility in the Danish strait in the Strait between Iceland and the Faeroes Islands of creating systems for long-range detection of submarines, which, in their opinion, will expand the capabilities of application of antisubmarine aircraft.

Equipment of the Baltic and Black Sea strait zones in antisubmarine respect and the maintenance of operational conditions there, which prevent the passage of submarines, were placed on the naval forces of NATO countries, located near the zones, by the American command: Great Britain, FRG, Denmark, Norway, the Netherlands, Turkey and Greece. Along with the utilization of positioned antisubmarine facilities and antisubmarine ships here it is proposed to apply antisubmarine aircraft and primarily helicopters.

Antisubmarine warfare in the Pacific theatre of military operations. In recent years the Pentagon has given increasingly greater attention to the creation of antisubmarine barriers and zones in the Pacific Ocean theatre (Fig. 50). The efforts of the U. S. Naval Command on the Pacific Ocean are primarily directed to the creation of effective stationary systems for long-range detection, classification of underwater targets and tracking them, which, in the opinion of American antisubmarine warfare specialists, considerably increases the capabilities of application of land-based antisubmarine aircraft.

As is known from reports of the foreign press, the U. S. Navy plans to create on the Pacific Ocean a long-range submarine detection system, similar to the "NORAD" air defense system.[1] The purpose of the long-range detection system - centralization of collection and processing of all incoming information about the location and activity of enemy submarines on the Pacific Ocean with automatic reflection of the situation. For solution to the problem of

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[1]Navy plans Norad-type system in the Pacific. "Missile Space Daily," 1966, Vol. 17, No. 14, 105.

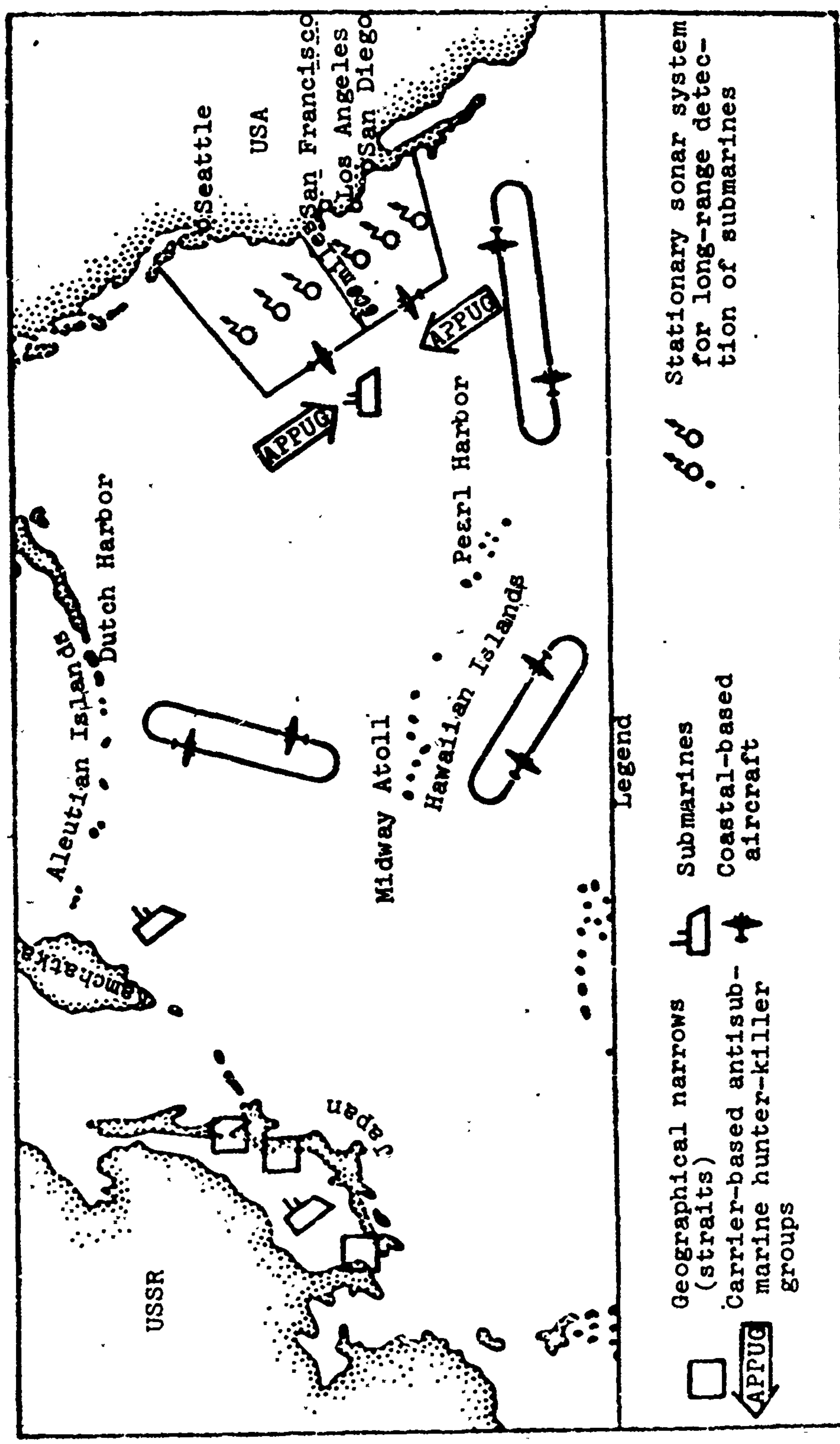

Fig. 50. Diagram of the location of antisubmarine barriers on the Pacific Ocean.

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antisubmarine warfare in the Pacific theatre in 1960 there were created antisubmarine forces, the composition of which includes eight operational units, so-called barrier forces of the Pacific Ocean Fleet. Barrier forces are intended for combatting submarines and patrolling the main antisubmarine barrier: Aleutian-Hawaiian Islands. Organizationally the barrier forces were reduced into an operational group, the composition of which included long-range radar detection aircraft and destroyer escorts.

According to reports of the American press, observation of submarines within the Pacific theatre is organized in three basic zones: in the foremost zone of antisubmarine warfare, in the zone between the Hawaiian and Aleutian Islands and in the zone of antisubmarine warfare of the Pacific coast.

The foremost zone of antisubmarine warfare encompasses the region of the western part of the Pacific Ocean from Kamchatka to the Philippine Islands. The Commander of U. S. Naval Forces in Japan is responsible for antisubmarine warfare in this zone. The foremost zone of antisubmarine warfare is subdivided into three regions: the first region stretches along the Kuril chain and the Kamchatka peninsula, the second region covers the Sea of Japan, and the third region – Japanese straits.

In the first region (along the Kuril chain and Kamchatka peninsula) the U. S. Naval Command intends to creat a barrier, which would exclude the possibility of unnoticed entry into the open ocean for enemy submarines. For observations of enemy submarines in this region it is proposed to use and there is practically now being used mainly aircraft of land-based aviation from the air bases of Japan and the Aleutian Islands (Adak, Shemya and Kodiak).

In the second region (Sea of Japan) observation of submarines is conducted by antisubmarine aircraft from Japanese airfields Atsugi, Iwakuni and others. The most intensive patrolling is carried out along the Soviet Littoral.

In the third region (Straits of Japan, La Perouse, Sangar, Sinomosek, Korean) observation of ships is conducted by antisubmarine warfare forces of the Japanese Navy.

The U. S. Navy Command gives the greatest attention to the creation of an antisubmarine barrier between the Hawaiian and Aleutian Islands. Namely on this barrier, depth 350-500 miles perpendicular to the axis of search of the islands of Oahu, Midway, Dutch Harbor, in the views of Americans, it is necessary to decisively countermeasure enemy submarines. The U. S. Navy specialists consider that this barrier will permit increasing the depth of approaches to the Pacific Coast of North America by 1500 miles. Already at present antisubmarine aircraft patrol here, operating from island airfields and ships of the antisubmarine forces of the Hawaiian naval region.

For combatting submarines at approaches to the U. S. Pacific Coast there is planned the creation of an antisubmarine barrier deeply distributed in depth up to 600 miles deep. On this barrier for detection and identification of submarines there will be used facilities of the long-range detection system, provided by the "Artemis" project and for tracking and destruction of submarines - antisubmarine aircraft and antisubmarine surface ships.

Arctic region. According to the numerous statements of American military specialists the Arctic in a future war is considered by the Pentagon as one of the important theatres of military operations.

The leadership of the U. S. Navy considers the Arctic with the seas adjacent to it as one of the regions where the American fleet will be deployed for operation of combatting submarines of the Soviet Union and preventing their entrance into the Atlantic and Pacific Oceans through the passage between Northern Norway and the straits of the Canadian Archipelago.

The mastering of Arctic regions began by the American Command even during the Second World War and was especially enlivened after its termination. There are already being conducted measures for operationally equipping the region, including the interests of submarine warfare. In the combat training of the U. S. and NATO allied naval forces considerable attention is given to development of assignments of submarine warfare at antisubmarine barriers and exits from the North Arctic Ocean into the Atlantic.

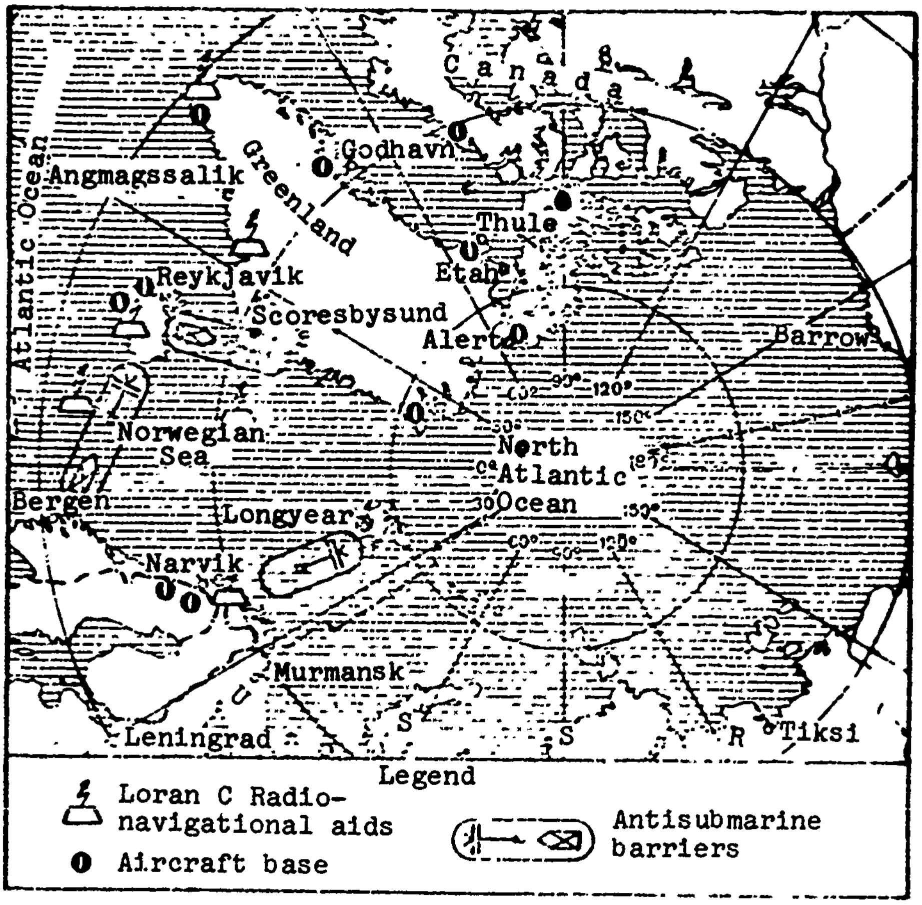

Fig. 51. Diagram of the location of antisubmarine barriers, airfields and radio navigation aids in the Arctic.

A considerable number of U. S. airfields are prepared in the northern regions of Canada. According to the foreign press, on only the territory lying around the polar circle, there are counted 26 airfields. Furthermore, according to American-Canadian agreements, made in 1947, the U. S. Navy even in peacetime can use the well-equipped air bases of Canada: Namao, Cloud Lake, Churchill, Ottawa, Ernst Harmon, Goose Bay, Argentia and Forbisher Bay. A diagram of antisubmarine barriers in the Arctic region is given in Fig. 51.

In the foreign press it was noted that the USA has reached an agreement with the government of Norway to build an air base on Spitsbergen Island.

Antisubmarine Aviation Tactics

The basic missions of U. S. antisubmarine aviation are search, detection, classification and destruction of submarines. It is considered that the utilization of antisubmarine aviation together with other antisubmarine forces will raise the effectiveness of accomplishing the shown missions. Therefore, the operational and tactical interaction of aviation antisubmarine forces with antisubmarine surface ships, submarines and positioned facilities is the basis of tactics of operation of antisubmarine aviation of the USA and other NATO countries.

Even at the beginning of the Second World War the U. S. Naval Command in collaboration with prominent scientists from American universities thoroughly studied the experience of military operations at sea and in particular the experience of combatting the submarines of fascist Germany. Enormous material was gathered on submarine warfare, which was conducted by the forces of the USA and Great Britain. This material served as the basis of a series of works on the experience of the combat activity of antisubmarine forces of the USA and Great Britain. During the investigation of questions of organization and tactics of antisubmarine warfare, the possibility

of utilization of technology and its further development the scientists revealed a number of interesting concepts, which determine the methods and tactical procedures of the struggle of antisubmarine forces against submarines of fascist Germany. On this basis there were formed recommendations on the development of aviation technology and perfection of antisubmarine aviation tactics.

One should note that in all cases, where the role and contribution of the armed forces of the Soviet Union in the matter of the crushing defeat of fascist Germany were first and foremost, there the American scientists, as a rule, maintain inadmissible modesty from the point of view of the historical truth. They simply hush up about the Soviet Union, as if it was not a decisive force in the crushing defeat of fascist Germany.

The systematic development of tactics of joint combat operations of mixed antisubmarine forces, including antisubmarine aviation, led to the creation in 1958 of the antisubmarine group "Alpha," and shortly after the groups "Bravo" and "Charlie."

The "Alpha" group in the beginning was occupied only with development procedures and methods of combatting conventional submarines. They became occupied with the development of means of combatting atomic submarines somewhat later, when the American command was convinced that the Soviet Union has considerable success in the construction of atomic submarines.

The main missions of these groups in peacetime are perfection of tactics and methods of interaction of surface ships, submarines and carrier-based antisubmarine aircraft of the U. S. Navy in combatting enemy submarines, and also refining methods of utilization of the new versions of antisubmarine weapons.

The U. S. Naval Command, placing before the "Alpha," Bravo" and "Charlie" groups the assignment of development of means of combatting atomic submarines, surrounded this fact with the development of

"defensive" measures to answer to the allegedly existing threat of aggression on the part of the Soviet Union. This is the usual method of American propaganda to make the Soviet Union the aggressor, and place itself in the role of the object, which can be subject to attack.

The bases of tactics of antisubmarine aviation are the methods and procedures of operations of single aircraft, helicopters and various aircraft groups when carrying out antisubmarine missions. Their correct application provides the greatest effect of utilization of airborne means of search and destruction of submarines in various weather and combat situations.

In contemporary conditions in comparison with other capitalist countries the USA have antisubmarine aircraft and helicopters, making up the overwhelming part of NATO antisubmarine aviation, considerable in number and the most perfect in technical relationship. In the postwar period the U. S. Navy conducted theoretical investigations and made many studies on antisubmarine warfare, in the course of which methods and procedures of operations of antisubmarine aircraft and helicopters were developed, were checked and were improved. Tactics, developed for American antisubmarine aviation, are widely used by antisubmarine aviation of the other capitalist governments. Therefore, below there is basically examined the tactics of land-based and carrier based antisubmarine aviation of the USA and there are noted features of its application with the aviation of other NATO countries.

Land-Based Aviation

Land-based antisubmarine aircraft constitute a considerable part of entire antisubmarine aviation in the USA. They are used in the system of an antisubmarine warfare for resolving the following missions:

1. Patrolling in the coastal zone, where usually a large number of ships and transport vessels pass between bases and ports.

2. Patrolling in the open sea for the purpose of general reconnaissance in the interests of antisubmarine warfare. This mission includes the search for rocket submarines in assigned regions of the ocean at a considerable distance (1500-1600 km) from the coast in the interests of disrupting their nuclear rocket strikes. Simultaneously base patrol aircraft ensure the joining up of combat ships and escorts during their passage through a given region of the ocean.

3. Patrolling on the boundary of the stationary means of sonar patrol (in the composition of the forces of the antisubmarine barrier). The solution to a given mission by base antisubmarine aircraft consists of flights along the barrier and the receiving of information from stationary hydroacoustic buoys about the noises fixed by them in the water medium. The information received is recorded by an airborne instrument on tape and then processed by airborne means for the exposure of noises of submarines.

On contemporary heavy antisubmarine aircraft electronic computers are used for this purpose. Upon exposure of the noise of a submarine which is fixed by any or several [RGB] (РГБ) sonobuoys in the region of the barrier, the aircraft establishes contact with it and if necessary destroys it. Information received by an aircraft from sonobuoys can be radio-relayed to shore or ship command posts.

During actions on antisubmarine barriers land-based (patrol) aircraft coordinate with surface ships and hunter-killer submarines. A basic difficulty in the organization and realization of coordination between antisubmarine aircraft and submarines lies in the absence of direct communication between them.

The antisubmarine aircraft which patrol the barrier cannot directly exchange reconnaissance information with the submarines which are found under the water, but must use a distant intermidiary shore command post, which leads to a loss of time. The position is further complicated by the fact that submarines on site (or in the zones of patrolling) only in exceptional cases allow radio transmission.

In the absence of communication in the aircraft-submarine-aircraft network there is the danger of a strike on submarines by their own aircraft. Because of this, as it is possible to judge based on materials of studies, the possibility is excluded of the joint combat actions of antisubmarine aircraft and hunter-killer submarines in the same zone and the flight of aircraft over the region of patrolling of submarines. In general (Fig. 52) during the joint actions of submarines and antisubmarine aircraft in the composition of the grouping of antisubmarine forces for a barrier, as a rule, belts for the patrolling of antisubmarine aviation are assigned with the calculation that between them and the positions of boats there would be a belt of such a width that even in the case of coarse navigation errors by the crew the possibility of flight of antisubmarine aircraft over the positions of hunter-killer submarines would be excluded. Usually the belt of the position of hunter-killer submarines is inverted to the side from which the approach of enemy submarines is most probable. These foreign specialists explain by the fact that, in the first place, hunter-killer submarines still possess more effective means than antisubmarine aircraft for the detection of underwater targets, and in the second place, and this is main, the antisubmarine aircraft are the maneuverable means in the composition of the forces of antisubmarine warfare. They are capable based on the information of hunter-killer submarines to concentrate rapidly and begin combat actions at any section of the antisubmarine barrier.

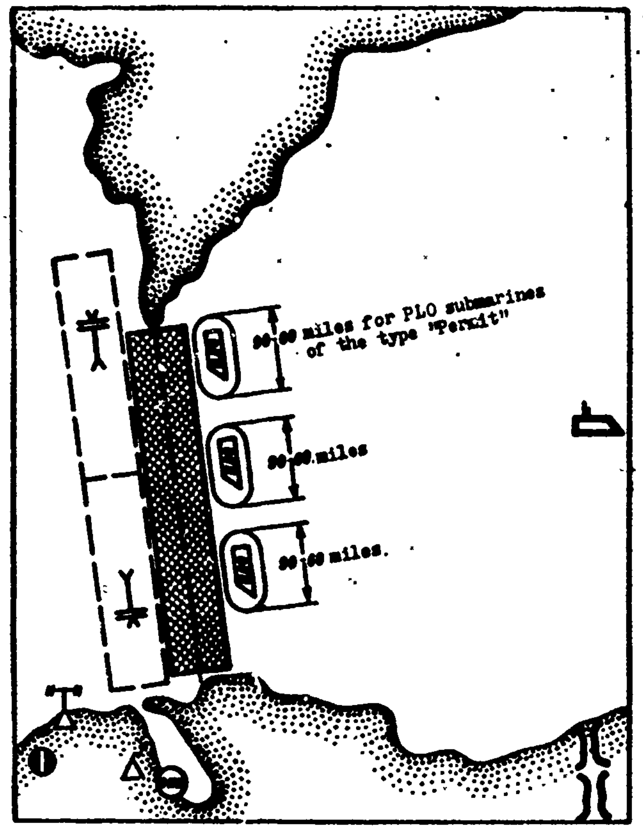

Fig. 52. Arrangement of segments of belts for patrolling of antisubmarine aircraft and the zones for hunter-killer submarines for joint actions on an antisubmarine barrier (a variant).

Designations: ПЛО = PLO = antisubmarine defense; ВМБ = VMB = naval base.

4. The investigation of a zone (search in a zone), where earlier by other antisubmarine forces contact was established with an underwater target. The success of an aircraft establishing contact with an underwater target and its classification depend to a considerable degree on the extent of the area of search, within the limits of which the underwater target can be found. The dimensions of this area at the moment of arrival of the aircraft into the area depend on the following factors:

1) the distance of the region, the proposed site of an underwater target, from the aerodrome, from which the antisubmarine aircraft fly out in case of an alarm;

2) speed of the aircraft during flight to the region of search;

3) probable speed of the underwater target (submarine). Usually they take the maximum speed of a submarine of that class, which based on the conditions of the operational situation, could be found in the given region;

4) time from the moment of detection of the underwater target to the alert of the aircraft. The boat can be detected by a ship, another aircraft, a commercial vessel, or stationary means of distant detection. The total time T is made up of the time for the report about the detection of an underwater target t_1, the time for making the decision and issuing the order for the sortie of the on-duty aircraft to search for the underwater target and establish contact with it t_2, and time for the crew to prepare for flight and the flight of the aircraft t_3:

$$T=t_1+t_2+t_3.$$

The further the region where the submarine was detected from the aerodrome of land-based aviation from which the aircraft takes off, the less its speed in flight from the aerodrome to the region of search (the speed of assault), the greater the speed of the submarine, and the greater the interval of time from the moment of detection of the submarine to the sortie, than the greater will be the area of the region of search in which the submarine can be found at the moment of arrival of the aircraft into the assigned region.

Assume, as is shown in Fig. 53, that in region A on the coast there is an aerodrome of land-based aviation, at point B - a coastal command post [CP] (КП) for antisubmarine warfare, and at point O a submarine was detected. The submarine can be found within the limits of the area of a circle with the radius R, if it moves on a straight line at maximum speed $V_{пл}$ along one of the radii, and being removed from point O during the time from the moment of its initial detection to arrival the patrol aircraft at point O. Then

$$R=\left(\frac{D}{V_c}+T\right)V_{пл}$$

and the area of the region of search

$$S=1,57\left[\left(\frac{D}{V_c}+T\right)V_{пл}\right]^2.$$

where V_c - the speed of flight of the aircraft from the aerodrome to the center of the region of search.

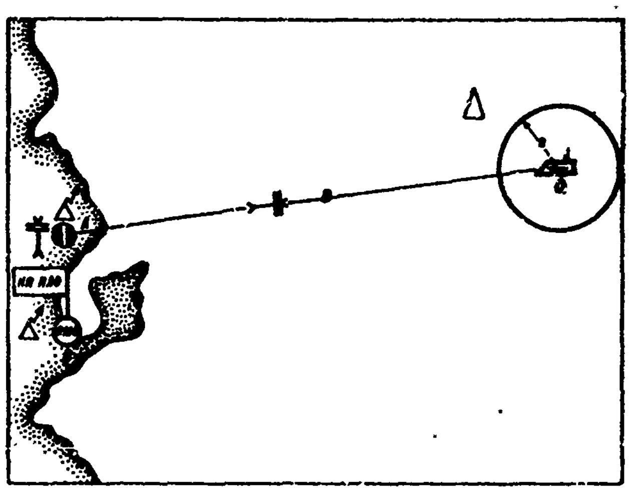

Fig. 53. Calculation of the area of search for a submarine by a land-based antisubmarine aircraft in an alert sortie.

The high-speed means of communication utilized in the USA make it possible relatively rapidly to transmit information about the detection of a submarine to a coastal (ship) command post and from it to transmit the command for a sortie by stand-by aircraft. Roughly the total time T, necessary for the transfer of information about the detection of an underwater target, issue of the command for a sortie, the starting of the engines, taxiing, and the flight of the aircraft, will take about 3-5 min on the condition that the crew clarifies the mission in the air.

Let us take for an example: D = 1000 km; $V_{пл}$ = 32 knots (approximately 60 km/h); V_c = 600 km/h; T = 5 min (0.08 h).

Let us substitute the values D, $V_{пл}$, V_c and T taken by us in the afore-cited formula and determine:

$$R=\left(\frac{1000\ \text{km}}{600\ \text{km/h}}\ 0{,}08\ \text{h}\right)60\ \text{km/h}=105\ \text{km};$$

$$S=\frac{3.14\,(105\ \text{km}^2)}{2}=1{,}57\times 11025\ \text{km}=17309\ \text{km}^2.$$

The calculated area of the circle is approximately equal to the area of a square with sides of about 131.5 km.

One ought to keep in mind that during the time of search for the submarine by the aircraft the investigated area in comparison with the area in the beginning of the search increases proportionally to the ratio $\frac{V_{уд}}{V_{с.п}}$, where $V_{с.п}$ - the speed of the aircraft during the search for the submarine.

These very simple calculations explain the striving of the English and Americans to increase the speed of assault of carrier and land-based antisubmarine aircraft while maintaining as little speed as possible in patrolling, i.e., to develop antisubmarine aircraft with a wide range of speed. Also entirely explicable is their tendency to approximate the aerodromes of land-based antisubmarine aviation to the main antisubmarine barriers. Also understandable is the development, being planned by the U. S. Navy, of heavy antisubmarine aircraft with a large carrying capacity and range of flight, capable of patrolling an antisubmarine barrier for several days.

Antisubmarine Helicopters

The antisubmarine helicopters, included in the armament of the naval forces of the USA, Great Britain, and other capitalist countries, are used:

- from antisubmarine aircraft carriers;

- from destroyers, frigates, and patrol ships.

They are piloted and pilotless radio-controlled.

The advantages of piloted helicopters are:

- a high, in comparison with antisubmarine ships, speed of the search and pursuit of a submarine.

- the capability of a sudden appearance over the region of finding of a submarine, where a helicopter, remaining unnoticed by the submarine, with the help of sonar can establish and maintain contact with it.

Submarines still cannot take active countermeasures against antisubmarine helicopters. Therefore helicopters can be used effectively as on-board means of search and destruction of submarines.

Along with the mentioned advantages antisubmarine helicopters have shortcomings, chief of which is the difficulty, and sometimes impossibility, of using them in bad weather even in the presence of means of self-stabilization. Furthermore, all helicopters upon approaching the point of contact, before beginning the search have to eliminate forward speed, unroll against the wind, and take up

an appropriate position for lowering the sonar, for which time is necessary. On the operation of the sonar a certain complicating influence is exerted by the air stream from the rotor and the vertical movements of the helicopter under the influence of "bumpiness" over the sea.

The effectiveness of the search for submarines by a piloted antisubmarine helicopter is characterized by its search speed, i.e., by the extent of the area covered in one hour, and by the probability of detection of a submarine. The sequence of actions of the crew of an antisubmarine helicopter during the search for a submarine with the help of sonar is shown in Fig. 54.

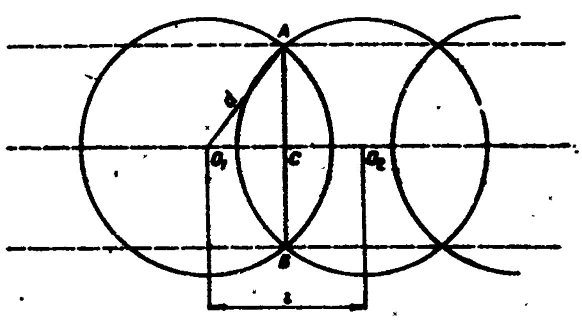

Fig. 54. Calculation of the width of the belt of effective search by an antisubmarine helicopter using lowered sonar.

A helicopter at an altitude of 10-15 m hovers over the calculated point O_1 and, having lowered the sonar acoustic system on a cable, carries out location for 2-3 min. If a submarine is not detected, the crew raises the sonar and flies to the following point O_2, separated from O_1 by a certain distance i, where the operation is repeated.

Foreign specialists recommend in the calculations to assume $i=1.25d-1.6d$, which, in their opinion, ensures the optimum amount of area covered in one hour, and the acceptable probability of detection of a submarine.

Considering the right angled triangle O_1AC (Fig. 54), it is possible to write

$$AC=\sqrt{AO_1^2-CO_1^2},$$

where $AO_1=d$ - the range of detection of a submarine with the help of lowered sonar, which depends much on the hydrometeorological conditions in the area of search; $CO_1=\frac{i}{2}$, where i - the distance between two points of hovering of a helicopter during a search with covered sonar; $AB=2AC$ - the width of the effective belt of search $Ш_{эф}$.

In general $Ш_{эф}=2AC=2\sqrt{d^2-\left(\frac{i}{2}\right)^2}$. For an example let us assume that $d=4$ km; $i=1{,}25d=5$ km. Then $Ш_{эф}=2\sqrt{4^2-\left(\frac{5}{2}\right)^2}=2\cdot 3{,}12=6{,}24$ km.

The search for submarines can be conducted by a group of helicopters in a specific formation. In these cases the interval between helicopters in a formation will equal 0.8-0.9 the width of the belt of the effective search of a single helicopter.

Let us assume, as this is done by Anglo-American authors, that the average speed of a planned helicopter during flights between points of hovering is 180 km/h (94 knots). Then at i = 5 km the flight from point to point (in a calm) will take 1.6 min.

Some calculation characteristics of helicopter search are given in Table 5.

Table 5.

Effective range of sonar, m	Distance between stations, km, at		Width of the belt of effective search, W_{eff}, km, at		Time of flight from station to station, min, at		Time of investigation at one station, min	Overall time of one cycle T, min, at		Average rate of the search km/h, at		Investigated area, km²/h at	
	f = 1.5f	f = 1f	f = 1.5f	f = 1f	f = 1.5f	f = 1f		f = 1.5f	f = 1f	f = 1.5f	f = 1f	f = 1.5f	f = 1f
1830	2,23	2,9	2,8	2,2	0.6	0,8	3,0	3,6	3,8	30,0	46,0	109,0	103,0
3650	1.6	5,9	5,7	4,4	1,2	1,6	3,2	4,4	4,8	63,0	74,0	360,0	325,0
5500	6,9	8,9	8,6	6,6	1,8	2,4	3,5	5,3	5,9	78,0	91,0	671,0	600,0
7315	9,2	11,7	11,4	8,8	2,4	3,2	3,7	6,1	6,9	90,0	103,0	1096,0	895,0
9150	11,0	14,6	14,3	11,0	2,9	4,0	3,8	6,7	7,9	102,0	112,0	1457,0	1220,0
10970	13.7	17,6	16,9	13,0	3,5	4,8	4,1	7,6	8,9	107,0	119,0	1808,0	1670,0
12800	15,9	20,5	20,9	15,6	4,1	5,6	4,3	8,4	9,9	114,0	126,0	2280,0	1940,0

Note. For calculations data were used from the article by Treacher "Some aspects of ASW in the Royal Navy." U. S. N. J. P., 1966, X, Vol. 92, No. 10, pp.152-156.

In the calculations it was assumed:

- the average speed of flight of the helicopter - 180 km/h;

- i = 5 km;

-the time of investigation at one station[1] - 3 min.

From Table 5 it is evident that the extent of the investigated area depends on the effective range of the sonar more than on the speed of flight of the helicopter between hovering points.

With a 6000-7000 m effective radius of helicopter sonar the hourly efficiency of the antisubmarine helicopter in the search for a submarine in a submerged position is double the hourly efficiency of surface antisubmarine ships.

The English specialists of antisubmarine warfare consider that organization and tactics of application of antisubmarine helicopters are determined mainly by the capability of the submarine to elude detection, which depends:

- on the relationship of the rate of search of the helicopter and the speed of the submarine;

- on the relationship of the area of simultaneously investigated zone and area of the zone of possible location of the submarine;

- on the number of helicopters used simultaneously.

During the search for a submarine it is practically impossible to influence the first two factors. The unique possibility of increasing the success of a search is the simultaneous utilization

[1]Investigation at one station includes the lowering of the vibrator on cable to the desired depth, the locating search, and lifting the emitter from the water before the flight to the next station.

of a considerable number of means of detection, in this case of helicopters, for which their rapid concentration in the region of search is necessary.

In the opinion of the English, for example, the successive utilization of 12 helicopters, each of which conducts a search for 2 hours a day, is less effective than the simultaneous utilization of 12 helicopters for 2 hours.

In the English fleet the feasibility of helicopters for antisubmarine search is evaluated according to the following norms.

The combat composition of the helicopters, i.e., the number of helicopters ready for fulfilling combat mission - 65-70% of those on hand.

The norms of flight time of helicopters:

- average monthly norm per helicopter 80 h;

- average daily per helicopter 2 h 40 min;

- maximum daily per helicopter 18 h.

The number of personnel to a helicopter:

- flight and reserve of 6 men;

- specialists for ground maintenance 10 men.

The flying time for one pilot:

- maximum flying time for a month 80-100 h;

- average flying time for a month 45-50 h;

- daily norm under strained conditions 9 h in two days;

- daily norm under normal conditions 4-5 h in 10 days.

In order to determine the position of a submarine relative to the helicopter and the parameters of its motion, the crew has to maintain contact with detected submarine for 6-10 min.

One antisubmarine warfare [ASW] helicopter with sonar, as considered by English specialists, is not in a position to maintain constant contact with a high-speed and maneuvering submarine and cannot get closer to it than a distance of 1800-2700 m.

Therefore in English fleet an effective tactical group for the search and destruction of a submarine is considered a group consisting of two hunter-killer helicopters.

Based on the material of the press, all antisubmarine actions with the participation of helicopters are divided into two categories:

- actions on a wide scale, not connected with the antisubmarine defense of any object;

- actions against submarines which are threatening a defended object.

Actions on a wide scale include the search and destruction of submarines by ASW forces at antisubmarine barriers; which are set up in narrow or insular regions, and also in zones of the open sea which are limited in area.

English naval specialists consider that after the zone of search is determined the tactics of concentric envelopment by helicopters practically deprives the submarine of the possibility of using its high speed for evasion.

Figure 55 depicts the arrangement of the concentric search for a submarine by a group of helicopters in a limited region, where according to the data of reconnaissance (stationary means of sonar observation, a radio interception, patrol ships, and others) a submarine has been detected or is suspected. It is assumed that the helicopter will arrive at the initial points for the beginning of a search with a time lag of up to one hour relative to the moment of the initial receipt of information about the detection of a submarine.

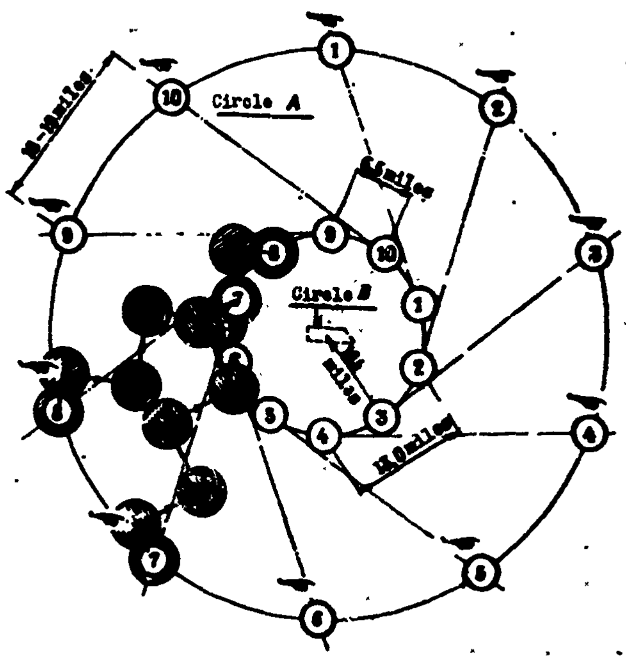

Fig. 55. The arrangement of the concentric search for submarine in a submerged position by a group of helicopters.

As it appears from Fig. 55, in a concentric search 10 helicopte. with sonar can take part. In the example being considered the effective range of the sonar is d = 9150 m (4.95 miles), the rate of search is accepted as 60 knots (110 km/h), and the maximum speed of the submarine 30 knots (55.5 km/h). The first helicopter arrives at the assigned point on circle A with a delay of 35 min, and the last - 60 min. Thus, at the moment of arrival of the last helicopter the

submarine, which was found (supposedly) at point O, even at maximum speed will not be able to move unnoticed beyond the limits of circle A.

The sequence of actions of antisubmarine helicopters in a concentric search is such. The helicopters arrive at their assigned positions on the circle and fly defensive patrol on them until all the helicopters occupy their positions. Then on command each helicopter in its own direction begins a sychronized search on a zigzag line with an angle of 45° and at calculated points lowers the sonar for a hearing.

As soon as any of the helicopter crews detect the enemy submarine another nearest helicopter joins the first, and by joint efforts they specify the coordinates and if necessary destroy the sub.

If the sub is not detected, then after every helicopter reaches its position on circle B the even (2, 4, etc.) helicopters can be directed to a new region for the formation of a new circle A, but the remaining odd ones (1, 3, etc.) form a so-called "impassable" barrier on circle B. The distance between the helicopters which create the "impassable" barrier is 13 miles. The area of the investigated zone, limited by circle A, comprises about 4000 square miles. The duration of investigation is about one hour.

Control of ten helicopters, which should guarantee them an exact approach into the initial points on circle A, the maintaining of their place up to the beginning of the search and the observance of such a mutual position during the entire investigation, which would exclude the unnoticed breakthrough of the submarine from the zone of the concentric search, is a complex mission in its practical solution. It is considered necessary for control to have specially equipped aircraft and surface ships.

In the distant protection of heavy and particularly important convoys at a distance of 40 miles and more from the extreme vessels of the convoy in the direction being threatened can follow a carrier-based hunter-killer antisubmarine group. For observation of submarines the antisubmarine aircraft of such a group can set up barriers of sonobuoys. Even at the greatest distance from a convoy the most threatened direction is patrolled by land-based aircraft which are supporting the [APPUG] (АППУГ) carrier-based antisubmarine hunter-killer group.

If one were to judge from the statements of the ASW specialists of the English fleet, then the main, and it seems, singularly feasible mission of the antisubmarine protection of convoys and formations of ships is to agitate a submarine to attack the protected object.

For this a curtain of antisubmarine helicopters and ships is created at a sufficient distance from the protected ships (transports) and it is retained up to the elimination of danger. The density of the curtain should be such that a submarine during an attempt to penetrate through the curtain in order to make an attack in all cases is detected. But the creation of a curtain from ships and helicopters is not a simple assignment from the point of view of organization and control.

Creation of a "puncture-proof" curtain requires the employment of considerable forces. The latter is caused by the high combat capabilities of atomic submarines, and in the first place by the considerable underwater speed and the range of torpedoes, which in the opinion of the English will be the basic combat boats for actions against transports and combat ships, and also by the considerable area over which a convoy has to be spread which is traveling in an anti-atomic formation.

Thus, for example, a contemporary convoy made up of 50 ships and transports occupies an area of about 450 square miles (a circle with a radius of 12 miles).

It is assumed that a submarine can attack with torpedoes from a distance of 8 miles. Under such conditions the curtain should be disposed along a circle with a radius of 20 miles, i.e., extend along a perimeter of 120-130 miles.

Assuming the radius of action of helicopter sonar as 9150 m (4.95 miles), for the achievement of acceptable reliability of search for submarines and the impenetrability of the curtain it will be required to have in a curtain 10-11 helicopters or 13-14 surface antisubmarine ships. But in order to have 10 helicopters in the air constantly it is necessary to have 40 helicopters. The latter, based on a number of circumstances and on economic considerations, is apparently excluded. Furthermore, complex hydrometeorological conditions, for which the North Atlantic is especially "famed," frequently are excessive even for all-weather antisubmarine helicopters. A general case is envisaged when the antisubmarine protection of a convoy will be carried out by the forces of several antisubmarine ships and 2-3 continuously flying defensive patrol helicopters.

The afore-cited considerations, the English specialists of the antisubmarine warfare and convoy service assume, cause the need to have piloted antisubmarine helicopters on ships in the class of destroyer escorts, destroyers, and frigates.

In order that the antisubmarine curtain of a convoy have 2-3 helicopters continuously, it is necessary that on the ships there be 6-9 helicopters, because one third of them will always be found in preventive maintenance and repair. With a norm of flight of 80 h a month for a helicopter and the presence on the protecting ship of 2-9 helicopters they can be used on the average no more than nine days a month, but for this it will be required to have one and a half complete sets of crews.

From the point of view of convenience, effectiveness of control, and economy of operation of helicopters it is considered expedient that all 6-9 helicopters be placed on one ship. However, for this it would be required to build expensive special ships, such as helicopter

carriers, which apparently in the English fleet is not considered a singularly correct solution. An acceptable variant, in the opinion of the English ASW specialists, would be the distribution of the shown quantity of antisubmarine helicopters on two-three ships.

Today and, as is proposed, in the nearest future, every screening ship should have an antisubmarine helicopter. Below an example is given of the calculation of the cost of the solution of the standard mission of combatting submarines with the help of helicopters, carried out according to the English procedure and making it possible to imagine the sizes of the investments for antisubmarine mission which fall on the shoulders of the working man in the USA and other capitalist states, for covering a water region with an area of 50,000 square miles in 11-12 h with an average frequency of 1.3 times a day for one year. Under average bathymetric conditions the effective range of helicopter sonar is taken as 3 miles (5500 m). By the way let us note that area taken in the calculations can be presented in the form of belts 1000 × 50 or 100 × 500 miles within the limits of the antisubmarine barrier.

For solving the mission it is necessary to have 100 helicopters with an average annual coefficient of utilization of 65-70% and an annual resource of 100,000 flying hours.

In a year 24 million square miles of water surface can be covered and in 11-12 h flying time a day - about 65,000 square miles, for which will be required three flights each by 20 helicopters.

The overall number of personnel is 1600 men, of which 300 are pilots. The overall cost only for the operations of helicopters and base maintenance will comprise about 65 million pounds sterling without expenditures for control.

Radio-Controlled Helicopters

The radio-controlled antisubmarine helicopters of the system [DASH] (ДЭШ) destroyer antisubmarine helicopter are a weapon which is controlled from on board a ship. Therefore when we speak about the tactics of antisubmarine helicopters in the DASH system, it is more correct to speak about the tactics of destroyers and destroyer escorts which use radio-controlled means for the defeat of submarines.

Upon detection of a submarine by ship sonar and the more or less reliable identification of it the decision is made to launch a DASH helicopter. From the carrier-based control panel the commands for flight are issued to the helicopter. Then through the system of radio control the helicopter is supplied with the appropriate commands which indicate the direction of the target. With the more precise clarification of the parameters of movement of the submarine by the ship sonar station from the shipborne control post specifying commands about its course, speed and altitude of flight are transmitted to the helicopter. The antenna systems for radio control of the helicopter are calculated for operating in the zone of direct visibility.

After the helicopter gets on the assigned course, control of it is transferred to a second shipborne control post located in the combat information center [BIP] (БИП). On the basis of the data of shipborne sonar, with the help of the appropriate commands the pilotless helicopter should be led out to a point over the enemy submarine.

After it is determined at the command post of the ship that the mutual locations of the helicopter and the submarine allow the using of a weapon for destruction of the submarine, the helicopter is given the command for the dropping of a torpedo or a depth-charge, whereupon it returns to the ship for a landing. When the helicopter

approaches the ship control is transferred to the deck panel, which with the help of a special system [LAD] (ЛАД) location aid device ensures the landing of the helicopter on the deck of the ship.

But the helicopter in the DASH system possesses a substantial shortcoming, which, as the Americans consider, limits its combat capabilities. Thus, with the launching of the antisubmarine torpedo with the help of the rocket "Asroc" it is assumed that the target has been identified as an enemy submarine. When using a radio-controlled helicopter of the type QH-50C of the DASH system the possibility is still excluded of identifying ahead of time, with the necessary reliability, that the underwater target is actually a submarine. The need for this always arises, especially when the target is detected at a great distance (in the zone of convergence), i.e., beyond the limits of range of the direct action of the shipborne sonar.

Nonidentification of targets can frequently lead to the use of torpedoes on whales, schools of fish, etc. Hence it is understandable, why the U. S. Navy is studying the problem of improving the tactical characteristics of the DASH system, which would make it possible from the helicopter to preliminarily specify the data about the nature of a target, detected by shipborne sonar at a great distance, and reliably identify it.

Strong wind and rough seas complicate, and sometimes exclude the possibility of flight and the landing of a helicopter in the DASH system. This is also a significant shortcoming of the radio-controlled helicopter, especially since in the regions of the North Atlantic a large part of the year consists of unfavorable weather. As concerns the possibility of the application of a nuclear weapon from the helicopters in the DASH system for the defeat of submarines, which would allow for an overlapping of errors in determining the parameters, location, and movement of a submarine, then, as is asserted in the foreign press, the leaders at the Pentagon consider that greater attention in the development of means for destroying submarines will be given to conventional weapons, and not atomic.

A ship which is maneuvering in combat situation apparently will not take on deck a helicopter which has expended its weapon and the helicopter will be lost, which also cannot be referred to the advantages of the system.

The utilization of piloted helicopters of the type "Wasp" on English antisubmarine ships in the opinion of the specialists of antisubmarine warfare from Admiralty is more advantageous. The helicopter "Wasp," based on destroyers and other ships, combines in itself the advantages of a shipborne long-range carrier of the means of the annihilation of submarines analogous to the helicopters in the DASH system. Besides this, which is especially important, the crews of helicopters of the type "Wasp" with the help of airborne means for search and tracking can conduct an independent search for a submarine and maintain contact with it if it is found within the limits of the shadow zone, located between the zone of convergence and the zone of the direct influence of shipborne sonar.

The tactics of piloted antisubmarine helicopters of the type "Wasp," based on destroyers or frigates, are following. After detection of a submarine by the shipborne sonar, on the decision of the captain of the ship the helicopter takes off, and based on data from the combat information center (BIP) it follows in the region where the submarine was detected. Here the crew of the antisubmarine helicopter, receiving information about the current coordinates of the sub and its speed, with the help of sonar and RGB establish contact with the sub.

After this, having continued to receive information from the shipborne BIP, the helicopter occupies a position for dropping the means of destruction. In turn from the helicopter they automatically transfer data about the position of the sub and the helicopter to the ship. After dropping the means of destruction the helicopter observes the results of the attack and returns to its ship.

The Actions of APPUG Against Submarines

Carrier-based antisubmarine hunter-killer groups refer to the most important antisubmarine forces of the U. S. Navy. The Americans, in evaluating the testing of the combat preparation of APPUG in the post-war period, assert that their combat actions will be sufficiently effective also in the future.

The APPUG is used for the search and annihilation of submarines in the following cases:

- in the interests of the antisubmarine defense of carrier striking forces;

- for the antisubmarine defense of a large, particularly valuable convoy or series of convoys in a specific region for the continuation of some period of time;

- in the conducting of combat actions in the composition of ASW forces on important antisubmarine barriers.

During the antisubmarine protection of carrier striking forces [AUS] (АУС) carrier-based antisubmarine hunter-killer groups will enter the composition of these operational forces or act independently, conducting the search for submarines in front on the course or on the flank of the belt of movement of the AUS.

In the carrying out of combat missions three basic stages of combat actions of APPUG are considered:

1. A search in an assigned region of the ocean and the establishment of initial contact with submarines. In this stage they have in mind the establishment of radar contact, which is possible only when carrying out combat actions against diesel submarines.

2. A secondary search and the establishment of sonar contact with the submarine.

3. Pursuit and annihilation of the submarine.

During the first stage it is proposed to use the carrier-based antisubmarine aircraft of the type "Tracker," which with the help of radar, radio countermeasures, the "Sniffer" device, and other means allegedly are capable with a sufficiently high probability to detect submarines, traveling under a [RDP] (РДП) snorkel device or by periscope, and in a short time inspect extensive regions of the ocean. As the sources of primary information for APPUG about the establishment of contact with a submarine the American ASW specialists consider hunter-killer submarines, other ships, and vessels which are found in the region of the search, and are deployed in positions and coordinate with APPUG, and also systems for distant detection of submarines which are deployed on antisubmarine barriers.

For the search and establishment of primary contact with a submarine, depending on the geographical and hydrometeorological conditions, and also the operational situation in the region of search and the nature of the mission being executed by APPUG, various forms of maneuver of several carrier-based antisubmarine aircraft are applied. In diagram (Fig. 57) a variant is shown for the maneuvering of a carrier-based antisubmarine aircraft during the search and attack on a detected submarine which was applied on a number of exercises by the US fleet in the last 5-8 years.

a) b) c)

Fig. 57. A variant of the maneuvering of an antisubmarine aircraft for the search and attack on a submarine: a) beginning of search; b) establishment of contact; c) attack on the submarine.

The need for the second search for the submarine and establishing with it a new (still hydroacoustic), solidly maintained contact is caused by the impossibility of the prolonged maintaining of the primary, radar or other (nonacoustical) contact (the submarine may dive), and also by the difficulty of the determination of the precise location of the target with their help.

The second search is especially necessary when the information about the detection of the submarine is received from a ship, vessels and ASD submarines which are cooperating with APPUG. The second contact can also be established by the carrier-based antisubmarine aircraft of the type "Tracker" with the help of the systems "Jezebel" and "Julie." After specifying the location of the submarine the aircraft attacks it, using homing antisubmarine torpedoes and conventional or atomic depth charges.

The possibility is not excluded of the application of weapons based on the data of primary contact (radar). But, as the Americans consider, primary contact as a rule can serve only as the initial information for the organization of the second (sonar) search for a submarine. For solving this mission all the forces of APPUG are used: the carrier-based antisubmarine aircraft, piloted helicopters from the destroyers, destroyer escorts, frigates.

Antisubmarine helicopters from an aircraft carrier are used for the search of a submarine based on the data of primary detection and for the antisubmarine protection of the APPUG aircraft carrier itself.

In the first case with the approach of the aircraft carrier to the region of primary detection of a submarine the helicopters take to the air on their radius of action and immediately begin the search, using the lowered sonar.

The main share of the frigates and destroyers of the group, with the exception of two or three ships, which provide the direct (near) protection of the aircraft carrier and the safety of take-off and landing of aircraft, also is directed to the region of primary detection of the enemy submarine. There the ships are dispersed and they enter the search. If the helicopters are already there, then a joint sonar search will be organized, in which both the helicopters and the ships are designated their zones of search.

Overall control of the search is carried out from the antisubmarine aircraft carrier, which as a rule is found away from the region of detection at a distance which would hamper an attack by a submarine on the antisubmarine aircraft carrier. The data about the surface, underwater, and air situation, arriving from the antisubmarine forces carrying out the search, are depicted in the BIP on plotting boards in the system "Iconorama," from which with the help of television they are transferred to the [VKP] (ВКП) mobile command post of the APPUG, the [GKP] (ГКП) main control room of the antisubmarine aircraft carrier, and to the posts for the preflight briefing of pilots.

For expanding the zone of radar observation of the sea and air, and also for the automatic relaying to the aircraft carrier of information from aircraft, helicopters, and antisubmarine ships of APPUG, the distant radar detection aircraft the Grumman "Tracer" is used (Fig. 58).

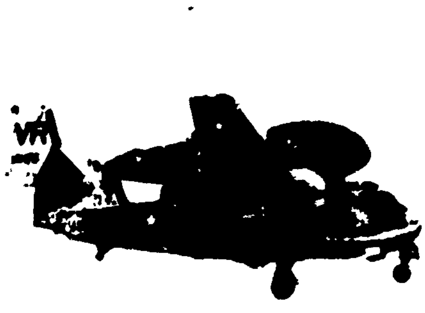

Fig. 58. The carrier-based radar patrol aircraft Grumman "Tracer."

Direct control of the antisubmarine ships, aircraft, and helicopters during the joint search for a submarine is assigned to the commander of the search, who is located on one of the antisubmarine ships. In material from the foreign press, which shed light on the course and results of a series of ASW exercises, the complexity of organization and especially the realization of coordination between antisubmarine helicopters and ships was noted. One of the difficulties (basic) is the danger of collision of antisubmarine ships and helicopters, especially during actions at night and under complex meteorological conditions. During the bright time of day the flights of antisubmarine helicopters are controlled by the leading elements, and during the dark time of the day - from surface ships.

The ASW specialists in the USA consider that the search for submarines by antisubmarine helicopters is possible only with a condition of the sea up to 4 points and visibility of the horizon from an altitude no less than 50 m.

The secondary search for a submarine ends either with the establishment of sonar contact with it, or the termination of search in the given region. In the course of secondary search the reliable classification of contact is considered particularly important, i.e., the precise establishment of whether or not the underwater target is actually a submarine. This is caused by the weak selective capacity of sonar stations, the high cost of antisubmarine weapons, and by the increased capacity of submarines for the creation of false targets. Based on experience of combat preparation the Americans assert that about 90% of the reports about the detection of a submarine by acoustic means are false.

The final stage of the actions of APPUG is the pursuit and annihilation of the submarine. In the opinion of the Americans, for the annihilation of contemporary submarines it requires several attacks

even when using antisubmarine torpedoes with homing guidance. Aircraft and helicopters at this stage can be used either for independent strikes or for guiding antisubmarine ships.

As the Americans assert, one of the means for carrying out an attack on a submarine by "Tracker" antisubmarine aircraft is guidance to the target, detected in a surface position or under a snorkel device, by the long-range radar detection aircraft "Tracer," which itself, as a rule, is found at a considerable distance from the submarine. In this case the strike aircraft does not turn on its radar, which increases the secrecy of its actions. But such a case is possible if the submarine does not have the means of radio intelligence or the commander of the sub regards the data of radio intelligence disdainfully. Such a case is also possible if the submarine for some reason or other cannot dive.

The guidance of antisubmarine aircarft and helicopters to a submerged submarine is carried out by helicopters, using the lowered sonar. For this the "Tracker" aircraft, when approaching the point of contact between the guiding helicopter and the submarine, uses an aeromagnetometer for establishing its own contact.

But nevertheless, as the Americans and English consider, the "main batteries" of APPUG are still the destroyers, frigates, and destroyer escorts, which can maintain prolonged contact with the sub, pursue it, and repeatedly make attacks on it. The application in this case of target-designating helicopters considerably enlarges the combat capability of surface antisubmarine ships. Evidently namely because of these considerations on English antisubmarine ships piloted helicopters with a considerable duration of flight are used.

In the foreign press it was indicated that, using antisubmarine missiles "Asroc" based on the data of antisubmarine helicopters, surface ships are able to attack a submarine while being situated

out of reach of homing torpedoes from the submarine. However, it was emphasized that the reporting of target designations by piloted antisubmarine helicopters for the firing of an antisubmarine rocket with an atomic charge, and also the use of atomic depth charges by these piloted helicopters is inexpedient because of the possible destruction of the antisubmarine helicopters by the atomic explosion.

For this very reason it is proposed to use radio-controlled antisubmarine helicopters as the carriers of atomic depth charges. In this case a radio-controlled helicopter is brought to the target by data from the sonar stations on the ships. The radio-controlled antisubmarine helicopter stays over the target for a certain time and then on command from a ship drops its homing torpedo or depth charge with an atomic charge. The loss of the helicopter in such a case is considered natural.

Combat Training of Antisubmarine Aviation

An important element in the system of preparations of the aggressive NATO bloc for war against the Soviet Union and the countries of socialism is the combat training of the naval forces, and their ASW ships and aviation.

The numerous exercises, conducted yearly within the framework of national forming and in the system of united naval commands, are directed so that the navies of the NATO countries will be ready:[1]

- to destroy the sources of a naval power of the USSR, primarily in the northern part of its territory;

- to gain supremacy in the Norwegian Sea for the purpose of not allowing the forces of the Soviet fleet to reach the Atlantic;

[1] "Our Navy," IX, 1967.

- to protect sea communications in the Atlantic between Europe and America, where more than 3000 commercial vessels are constantly on the move;

- to protect the North American and European continents from the strikes of enemy rocket submarines;

- to block the Soviet fleets in the Baltic and Black seas;

- to support the troops which are deployed in Europe with the forces of carrier-based aviation.

As was repeatedly emphasized in the foreign, and especially in the American press, in the five above-enumerated strategic missions one of the important elements in the maintenance of the combat activity of [OVMS] (OBMC) allied naval forces NATO is the conducting of ASW.

The combat training of antisubmarine forces in the fleets of the USA and other countries of NATO, and including antisubmarine aviation, is solved within the framework of national formings. In the USA considerable attention is given to the daily training of crews in antisubmarine aviation, for which considerable flying resources are set aside. As was noted in the American press, in the U. S. Navy allegedly no rigid annual limit exists on flying resources for the crews of antisubmarine aviation, or it is so large that it does not limit the capability of the commanders of air groups of carrier-based antisubmarine aviation in training the crews of antisubmarine aircraft and helicopters in missions dealing with the technology of piloting and the application of means of search and destruction of submarines.

In recent years, especially since the beginning of criminal war by the USA in Vietnam, antisubmarine aircraft carriers are at sea for a large part of the year, and for carrier-based antisubmarine aviation this presents wide possibilities for perfecting missions of combatting submarines.

The training of fliers for antisubmarine helicopters in the navy of Great Britain lasts on the average for about 22 months, moreover for the fulfilling of flight missions each flier is allotted almost 300 hours of flying in aircraft, helicopters, and trainers.

Staffing and training of crews for helicopters is done from the ranks of fliers from civil aviation who possess no less than five years of flying experience, cadre officers and specialists of the fleet, marines and naval aviation. Those accepted from civil aviation and the enlisted ranks of a fleet pass the first stage of instruction during 26 weeks at Dartmouth Naval College. Here is begun the initial flying training of the students, for which 10 h are set aside.

Having successfully finished the program of general officer training, they are sent to the air force school at Lintone. Also sent to this school are officers of the fleet and marines who have been selected for instruction on helicopters. For 18 weeks the students study technical and flying disciplines, and also receive 75 hours of flying practice in the aircraft "Chipmunk." No less than 90% of the students finish the school at Lintone and are sent to the helicopter school located at the naval air base at Culdrouse.

The naval helicopter school has a floating base of helicopters, the 705, 706 and 707th helicopter training squadrons, and a shore training complex. At Culdrouse the students receive their basic flight training.

In the 705th squadron the students are instructed in piloting on the "Hiller" Mk2 and "Whirlwind" Mk7 helicopters. For 18 weeks the students go through general daytime flying training and are instructed in piloting at night and by navigation instruments.

After termination of basic instruction at the school in Culdrouse and the passing of examinations the qualification of pilot is awarded to the students; the further improvement of training of the fliers for antisubmarine helicopters is conducted in the 706th squadron of the same school which has the "Wessex" helicopters.

The special training of pilots in the 706th squadron lasts for 14 weeks. During this period the students master the technique of piloting turboprop helicopters under simple and complex conditions, including instrument flying under conditions of poor visibility. From the beginning of instruction in the 706th squadron the students receive practice in operating helicopters, accomplishing many "flights" in the special trainer - a flight simulator of the "Wessex" helicopter.

The mastering of take off and landing on a ship is done at the floating base of antisubmarine helicopters "Lofoten."

In the 706th squadron there are "Wasp" Mkl helicopters on which the ablest fliers are trained. They have been selected for service in the 829th combat squadron, from which antisubmarine helicopters are sent out for outfitting guided-weapon destroyers (URO) and other ships of the fleet.

The last stage in the instruction of fliers for antisubmarine helicopters is carried out at the antisubmarine school of naval aviation at Portland. There they acquire skills in operating "Wessex" helicopters and together with the aircraft observers who are appointed to the crew master the skills in using sonar which has been lowered into the water.

The finalizing of the assignments of combatting submarines in the daytime and nighttime makes up the basic part of the concluding 9-week course of training for crews of antisubmarine helicopters, whereupon they receive an assignment to combat squadrons of antisubmarine helicopters, including the 829th squadron.

Special training in the 829th squadron takes six weeks. During this period fliers master the methods of attacking a submarine, flying by instruments, transporting of suspended cargo, and landing on small ships.

Considerable attention during class exercises on shore is given to the mastering of equipment on the "Wasp" helicopter, which is considered an important and necessary element of training. This is due to the fact that the helicopter crews themselves have to detect malfunctions when at sea on patrol ships of the "Leander" or "Trible" class.

Along with finalizing the tactics of carrier-based and land-based patrol (antisubmarine) aviation in the process of daily flying trailing of crews and in numerous antisubmarine exercises in recent years in the USA extensive use has been made of special trainers. In 1962 at the naval aviation station North Island the 2F-66 trainer was already being used. On it for 16 hours a day by turns the crews of antisubmarine aircraft were trained in the search and destruction of submarines. The cost of the trainer is 1.3 million dollars.

The trainer is disposed on two mobile vans, which makes it possible to move it between air bases. In one of the vans is the power pack and control board. In the other - the instructor panel and à compartment completely imitating the cabin of an S2F-3 aircraft with working places for every member of the crew. The trainer simulates very closely the practical conditions of search, detection, classification and attack on submarines.

Just as in actual flight during a search for a submarine, the commander pilots the aircraft, the copilot attends to the means of communication, the first operator - the radar set and aeromagnitometer, and the fourth member of the crew attends the "Jezebel" and "Julie" systems. On the trainer the standard sequence of the actions of the crew during a search, and the pursuit and defeat of a submarine with the utilization of various search equipment and the combat means of the aircraft are completely reproduced.

In the course of training during the normal course of flying time the instructor from his panel can introduce malfunctions and emergency conditions on the aircraft. During training it is possible

to present simultaneously two underwater and one surface targets, which maneuver in two- or three-dimensional space strictly in time corresponding to their tactical-technical capabilities; the conditions of the sea, the weather, the complex regularities of oceanic currents and temperature gradient of water are imitated, i.e., all those conditions, which influence the maneuvering features and combat capabilities of submarines and surface ships and antisubmarine aircraft. On the trainer it is possible "to freeze" the situation for a particular analysis in the course of training.

The systematic advantages of the trainer are that the instructor (teacher) with the help of the automatic recording of all the actions of the crew, in fixing the errors can interrupt the flight, stop, and even return in time in order to repeat an episode.

As was noted in the press, in the case of a one-hour utilization of the trainer the cost of one hour of training (amortization of equipment, power, operating personnel) is 155.4 dollars. The cost of one hour of flight training on an aircraft is 1500 dollars, without considering the cost of one hour of operation of the underwater target. It is still necessary to take into account the actual expenditure for RGB in the course of training flights on an aircraft. Each RGB costs about 150 dollars.

It was calculated that if in the course of three months a trainer is used for 16 h a day, then the total difference between the cost of training on a trainer and the cost of flying training with the use of underwater targets and expenditure of RGB will completely justify the expenditure for acquisition of a trainer.

In San Diego at the ASW school of the U. S. Navy a training complex for antisubmarine training has been constructed at a cost of 12 million dollars. The electronic equipment of the complex was developed and made by the firm Lockheed-Electronics.

The complex is a rather complex construction. It consists of the ASW tactics room and the trainer proper. The basis of the tactics room is an analog-digital computer from the firm Lockheed-Electronics.

The complex makes it possible to conduct the combat training of personnel from surface antisubmarine ships in coordination with antisubmarine aircraft and helicopters under conditions as close as possible to real.

With aircraft and helicopters it is possible to simulate utilization up to 64 RGB. The crews can operate the ships, aircraft, and helicopters only in a strict correspondence to their tactical-technical data, and control over the observance of this is done through a computer.

The entire course of training is recorded on magnetic tape, and during analysis a situation and action of the crews can be reproduced completely for any moment.

As noted by the ASW specialists, another advantage of the new ASW training complex is that all the changes in the tactical-technical characteristics of the ships, aircraft, helicopters, weapons, and equipment can be taken into account during programming on a computer and introduced into operating instruments.

In the tactical ASW training of officers in the British Navy at the school at Woolwich a tactical trainer is also used. On it the maneuvering and combat actions of 24 surface ships, aircraft, and submarines are simulated.

On joint naval exercises by NATO, in the composition of which are included the best trained units of the national fleets, basically the questions of control and coordination of the uniform and heterogeneous forces of different nationalities are mastered.

During the period 1964-1966 the joint NATO naval forces carried out a large number of exercises, in the course of which they also worked out problems of the antisubmarine defense of ship formations and convoys on sea journeys and dealing with atomic missile submarines during their penetration into the regions of the positions.

Interesting and characteristic from the point of view of the form of the application of antisubmarine aviation was the NATO naval exercise by the name of "Team Work" which was conducted during September 1964. It was conducted simultaneously with the NATO naval exercise in Europe "Fallex-64." The theme of the exercise "Team Work" was the inflicting of blows by nuclear and conventional weapons by the forces of the NATO shock fleet on objects in North and Central Europe.

A diagram of the actions of antisubmarine forces on the exercise "Team Work," compiled by the author based on materials from the press, in which the plan and the course of the exercise was illuminated, is shown in Fig. 59.

The exercise consisted of several phases. In the first phase (7-12 September) in the area south of Newfoundland a joint American-Canadian exercise by the name of "Master Stroke" was conducted. In the course of this exercise - the action of antisubmarine forces against atomic and conventional submarines "orange," developed in the course of movement of the American aircraft carriers, which were headed for the eastern Atlantic - the interaction of the carrier-based antisubmarine aviation, destroyers, and land-based aviation of the USA and Canada was worked out.

On the second phase of the exercise (21 September-2 October) the main mission was worked out - the inflicting of blows on objectives in North and Central Europe.

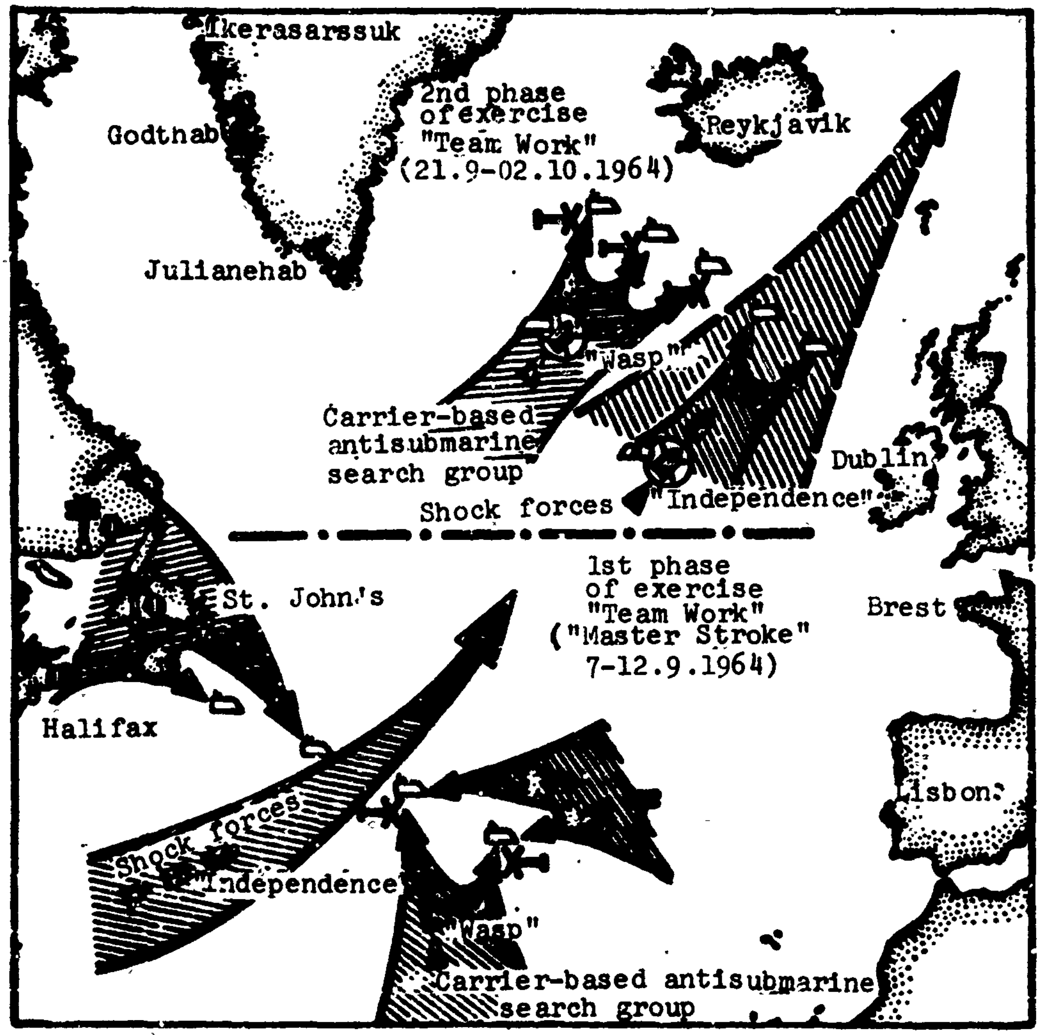

Fig. 59. Diagram of the actions of antisubmarine forces on the exercise "Team Work."

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At dawn on 21 September from the area south of Iceland the ships of the strike force at a high speed broke through the submarine barrier. The antisubmarine defense of this force during this period, as also during the previous passage from Newfoundland to Iceland, was made up of forces of antisubmarine aircraft and helicopters from an antisubmarine aircraft carrier "Wasp" working in conjunction with destroyers.

As stated by the commander of the antisubmarine force, on the given phase of the exercise the antisubmarine forces of the strike force detected and attacked only three "orange" subs out of 15 which were deployed for action against the strike force in the Norwegian Sea.

The English atomic submarine "Dreadnought," which was taking part in the exercise, successfully, i.e., with impunity, "attacked" the American strike aircraft-carrier "Independence," and an American sub also attacked unnoticed the antisubmarine aircraft-carrier "Wasp."

During December 1965 an exercise was conducted by the U. S. Atlantic Fleet, in the course of which methods of conducting landing operations were mastered. And in this exercise the antisubmarine defense of the landing during the sea passage was carried out by APPUG, i.e., by forces of tactical antisubmarine aircraft and helicopters of the aircraft carrier "Essex" working with destroyers.

From the point of view of the methods of an antisubmarine preparation, accepted in the NATO joint naval forces the antisubmarine exercise "Silent Run," conducted in the area north of Ireland from 19 September through 7 October 1966, was significant. It included antisubmarine forces from the navies of Great Britain, Canada, France, FRG, Netherlands, Norway, and Portugal.

The exercise was carried out by the cruiser "Tiger" from Great Britian, three destroyer escorts, the floating base of anti-submarine helicopters "Lofoten," two submarines, the 203rd squadron of "Shackleton" patrol aircraft from the air base at Ballykelly.

During the first ten days of the exercise the personnel of the ships and units carried out tactical training and mastered the methods of using weapons at the joint antisubmarine center for NATO at Londonderry (North Ireland), and from 1 through 7 October practical exercises were conducted in the sea and air on the search and annihilation of submarines.

In addition to this, in 1965-1966 another series of joint naval exercises by NATO was conducted in which other operational missions were solved. But in all the exercises a required element was the development of antisubmarine security of task forces and convoys (landings) by the forces of coordinated carrier-based and land-based (coastal) antisubmarine aviation and antisubmarine ships.

CONCLUSION

The radical changes which took place in the postwar period in the development of submarines, connected with achievements in the creation of atomic power plants and nuclear rocket weapon of the class "underwater-surface," substantially increased the striking power of the underwater fleet. Because of this there was noticeable increase in the role of antisubmarine defense in contemporary war. Specifically large changes occured in the development of antisubmarine aviation, which occupied one of the main places among other kinds of antisubmarine forces of the navies of capitalist states, and together with hunter-killer submarines, surface ships and stationary means of detection of submarines now constitutes their main antisubmarine defense.

Therefore the commands of the armed forces of the USA, other countries of the aggressive NATO bloc and Japan give a great deal of attention to the further perfection of antisubmarine aviation. In these countries they are working continuously on the development of new antisubmarine aircraft and helicopters, which possess higher flight characteristics and are equipped with the contemporary means of search and powerful antisubmarine weapons.

In the open foreign press frequently they exaggerate the capabilities of contemporary antisubmarine aviation and the aviation means of search and annihilation of submerged submarines. Still more exaggerated are the capabilities of future aviation means for the struggle with submarines.

However, in the USA, Great Britain, and other capitalist countries during the postwar years the periodic rearmament of antisubmarine aviation is actually being done.

They are accepting in their armament new antisubmarine aircraft, which in comparison with their nearest predecessors possess higher tactical flight qualities and combat capabilities. But, on the acknowledgement of Anglo-American naval specialists, the new patrol aircraft of land-based aviation, just as the modernized carrier-based antisubmarine aircraft, nevertheless do not satisfy the basic operational-tactical requirements stemming from the American-English concept of antisubmarine warfare (ASW). The "Orion," "Atlantic," and "Tracker" with their many flying and technical-operational advantages are able to conduct combat basically with diesel submarines. They still have insignificant capabilities for independent search, detection, and identification of contemporary atomic submarines.

The basic means for submarine search, which are utilized on contemporary land-based and carrier-based antisubmarine aircraft are radar RGB, and aeromagnitometers. Radar stations can be used basically for the search for diesel submarines when on the surface, traveling under a snorkel device, and at periscope depth under favorable hydrometeorological conditions.

Contemporary RGB possess a small range of detection of underwater targets even in a calm state of the sea. Sonobuoys have a short time of action and they are a very expensive means of single-time utilization. Therefore RGB cannot be applied widely by an enemy as a means of primary search for submarines in the extensive regions of the oceans and seas.

The distance of detection of submarines with the help of an aeromagnitometer is considerably less than with the help of RGB.

The carrier-based all-weather piloted antisubmarine helicopters, which are included in the composition of the antisubmarine forces of the fleets of capitalist states, and having in their armament the lowered sonar, can detect and attack submarines which are traveling deep. However antisubmarine helicopters have an inadequate speed of assault and with the small range of action of sonar an inadequate rate of search.

The limited capabilities of contemporary [OGAS] (ОГАС) dipping sonar based on range of detection, accuracy in determination of the point, and the parameters of movement and the identification of underwater targets far from satisfy the requirements for coping with contemporary and all the more so future submarines, as this is recognized by the Anglo-American ASW specialists themselves.

The duration of flight of antisubmarine piloted helicopters does not exceed 4.5-5 h, which at a rate of search of 80-100 km/h limits the zone of search by carrier-based piloted helicopters to a comparatively small region around the carrier ship. If necessary to carry out a search over an extensive regions it would be required to enlist the aid of a considerable number of helicopters and carrier ships.

In spite of this, the armament of destroyers, destroyer escorts, and frigates with antisubmarine helicopters in all the fleets of the NATO countries is considered as promising means, increasing the combat capabilities of surface ships in the struggle with submarines. In an American fleet today a system of ship-radio-controlled antisubmarine helicopter is applied. However, a tendency was already clearly noted for the transition from it to the system ship-light piloted antisubmarine helicopter.

The rearmament of coastal and carrier-based antisubmarine aviation of the USA and other NATO countries is part of the plan for the developments of antisubmarine forces and means which are calculated for a prolonged period. These plans provide for the further substantial

improvement of the tactical flight characteristics of aviation carriers with the means of search and destruction of submarines. Major capitalist states, and in the first place the USA, have for this an entirely contemporary aviation industry and a large number of generously financed and technically equipped firms and state scientific-research and development laboratories, stations, and ranges.

A great deal of value in the USA and other NATO countries is attached to the investigations and development in the area of perfection and development of the aviation means of search, detection, and classification of submarines. The perfection only of hydroacoustic means in the USA is engaged in by several hundreds of firms and organizations. Furthermore, extensive work is being done on the development of magnetometric and other nonacoustical means of search. At the basis of the further development of the airborne aviation means of search today lies their complex use in the joint search-sight system of the type "A-New."

Along with the shown trend of development in NATO countries considerable attention is given to the search for new principles of search (detection) for submarines and the development on their basis of various antisubmarine means in an aviation and ship-submarine variants. For this purpose abroad, especially in the USA, extensive hydrological-acoustic and the oceanographic investigations are being conducted.

Furthermore as testified to in recent communications from the foreign press, in the USA are boosted scientific-research and experimental works are being speeded up on the complex utilization of aviation and space means in the interests of antisubmarine warfare. A study has already been started on the possibility of the utilization of artificial earth satellites as retranslators of information about the underwater situation which is taken from RGB's which are put out by aviation or ships in the regions most probable appearance of enemy submarines.

Parallel with the development of means of detection of underwater targets and the carriers of these means in the capitalist countries intensive work is being done on the further perfection of antisubmarine weapons. New high-speed torpedoes with guidance systems acting on nonacoustical principles are being developed, and the conventional and atomic depth charges and antisubmarine mines are being improved.

In the leading naval circles of the USA and NATO they consider that in the seventies new aviation airborne instruments and combat means for search and detection of submerged submarines utilized in coordination with the new stationary means of detection of underwater targets which are created on antisubmarine barriers will possess a considerable distance of detection, a high degree of the probability of identification of underwater targets, and sufficient precision in the determination of their position and the parameters of movement. The expected progress in the creation of highly effective aviation means of detection and annihilation of contemporary submarines is one of the main prerequisites which determine the qualitative perfection of antisubmarine aviation observed in recent years in the USA, Great Britain and France, and its important role in the system of antisubmarine forces of the aggressive NATO bloc

Considerable attention is given abroad to the further perfection of organization, tactics of utilization, the system of basing, and of the outfitting of combat units of antisubmarine aviation.

All these measures are a component part of their predatory plans, since in the final analysis they are called on to ensure the solution of aggressive missions of the fleet in wartime.

It is entirely natural, that with such intensive preparation of imperialistic states for war the Soviet Union and other socialist countries, in conducting a decisive struggle for peace, are forced to take measures for strengthening the defense power of our country.

The growth of the technical outfitting of our naval forces is advancing increased requirements for the level of military-technical knowledge of personnel in the Soviet Armed Forces. Soviet soldiers must not only master to perfection the equipment entrusted to them, but also attentively follow the development of antisubmarine aviation and other ASW forces of the enemy.

Appendix 1. Tactical-Technical Data of Antisubmarine Aircraft Included in the Armament of NATO Countries.

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Country, name of firm, and aircraft	Year put out	Number of crew members	Number, type and power of engines	Maximum take-off weight, kg	Flying data: Maximum speed, km/h	Flying data: Range of flight, km	Armament
USA, Lockheed P2V-7 "Neptune"	1956	7	2 × 3700 hp Wright R-3350-32 and 2 × 1540 kgf thrust J-34 turbojet Westinghouse engines	34,000	680	6000	Cannons 2 × 20 mm, rockets 16 × 127 mm, bomb load up to 3800 kg, including two torpedoes, atomic depth charge
USA, Lockheed P-3A "Orion"	1961	10	4 × 4500 bhp, turboprop Allison T-56A-10W	58,000	750	8000	Torpedoes, conventional and atomic depth charges, 16 × 127 mm rockets, missiles. Maximum weight of armament 6800 kg
France, FRG, Breguet 1150 "Atlantic"	1961	12	2 × 6100 bhp, turboprop Rolls-Royce Mk21 "Tyne" Ty-20	42,500	620	9000	Torpedoes, all standard bombs accepted in NATO, the American and French depth charges caliber 175 kg, rocket missiles with armor-piercing heads of the type HVAR, atomic depth charge
Canada, Canadair CL-28 "Argus"	1958	15	4 × 3700 hp piston engine Wright R-3350 (Tc18E A1)	67,500	470	6700	Bombs, mines, homing torpedoes, guided rocket missiles. Maximum weight of armament up to 7000 kg

Appendix 1 (Cont'd.).

Country, name of firm, and aircraft	Year put out	Number of crew members	Number, type and power of engines	Maximum take-off weight, kg	Flying data		Armament
					Maximum speed km/h	Range of flight, km	
Great Britain Avro "Shackleton" M. R. 3	1955	10	4 × 2455 hp, piston engine "Griffon" 57A and 2 × 1120 kg thrust turboprop Vipers	45,960	500	7500	Torpedoes, depth charges, including atomic guided missiles, cannons 4 × 20 mm. General weight of armament up to 11,000 kg
USA, Grumman S-2D "Tracker"	1952	4	2 × 1525 hp piston engine Wright R-1820-82W	11,800	460	1600 to 2000	Torpedoes, depth charges, rocket missiles, 2 "Bullpup" guided missiles
France, Breguet 1050 "Alize"	1956	3	1 × 1975 bhp turboprop engine Rolls-Royce "Dart" Da 7 Mk21	8,200	460	1600	One homing torpedo or three depth charges inside the fuselage; two bombs and two guided missiles or six rocket missiles 127-mm on underwing holders

Appendix 2. Tactical-Technical Data of Antisubmarine Helicopters Included in the Armament of NATO Countries.

						Specific load	Speed of flight,		

Appendix 2. Tactical-Technical Data of Antisubmarine Helicopters Included in the Armament of NATO Countries.

Firm and designation of helicopter	Year put out	Number of crew members	Number, type and power of engines	Standard take-off weight, kg.	Load ratio, %	Specific load		Speed of flight, km/h		Range of flight, km	Armament
						per area kg/m^2	per unit of power, kg/hp	maximum	cruising		
Sikorsky SH-3A "Sea King"	1959	4	2 × 1250 hp, turboshaft General Electric T-58-8B	8060	36.8	29	3.22	240	185	925	Two torpedoes or depth charges, missiles
Westland "Wessex" H.A.S. 1	1958	4	1 × 1450 hp turboshaft Napier Gazelle NGa-13	5715	39.6	25	3.94	212	203	630	Two torpedoes or four wire-guided missiles Nord SS-11 t, "air-ship" rockets
Sud-aviation SA-3210 "Super-Frelon"	1962	-	3 × 1300 hp turboshaft Turbomeca Turmo IIIC-2	11,000	39.2	39.3	2.82	Up to 280	200	800	Two torpedoes
Gyrodyne QH-50C (radio-controlled)	1961	None	1 × 300 hp turboshaft Boeing T-50-Bo-8A	1045	49.5	19.6	3.48	112	-	Tactical radius of 37 km (duration of flight 1 h)	Two torpedoes Mk44 or one torpedo Mk46

Appendix 2 (Cont'd).

Firm and designation of helicopter	Year put out	Number of crew members	Number, type and power of engines	Standard take-off weight, kg	Load ratio, %	Specific load: per area kg/m²	Specific load: per unit of power, kg/hp	Speed of flight, km/h: maximum	Speed of flight, km/h: cruising	Range of flight, km	Armament
Gyrodyne OH-50D (radio-controlled)	1965	None	1 × 300 hp turboshaft Boeing T-50-130-10	-	-	-	-	-	-	Duration of flight 1 h 30 min. Tactical radius 40-65 km	The same as on the QH-50C
Westland " "Wasp" A.S. 1	1962	2	1 × 710 hp, Bristol Siddeley "Nimbus" 103 or 104	2495	-	32.71	3.5	193	177	435	Two torpedoes

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